

PB 200 078

AN FUNDAMENTAL ASPECT OF EMISSION SOURCES

MUNICIPAL INCINERATION

A REPORT BY J. J. STOKES

Reproduced by  
**NATIONAL TECHNICAL  
INFORMATION SERVICE**  
Springfield, Va. 22151

PB 200 078

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                        |                                                  |                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|--------------------------------------------------|--------------------------------------|
| <b>BIBLIOGRAPHIC DATA SHEET</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1. Report No.<br>AP-92 | 2.                                               | 3. Recipient's Accession No.         |
| 4. Title and Subtitle<br>Air Pollution Aspects of Emission Sources:<br>MUNICIPAL INCINERATION - A Bibliography With Abstracts                                                                                                                                                                                                                                                                                                                                                                            |                        |                                                  | 5. Report Date<br>May 1971           |
| 7. Author(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                        |                                                  | 6.                                   |
| 9. Performing Organization Name and Address<br>Office of Technical Information and Publications<br>Air Pollution Technical Information Center<br>Research Triangle Park, North Carolina 27709                                                                                                                                                                                                                                                                                                            |                        |                                                  | 8. Performing Organization Rept. No. |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                        |                                                  | 10. Project/Task/Work Unit No.       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                        |                                                  | 11. Contract/Grant No.               |
| 12. Sponsoring Organization Name and Address<br>Environmental Protection Agency<br>Air Pollution Control Office<br>Research Triangle Park, North Carolina 27709                                                                                                                                                                                                                                                                                                                                          |                        |                                                  | 13. Type of Report & Period Covered  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                        |                                                  | 14.                                  |
| 15. Supplementary Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                        |                                                  |                                      |
| 16. Abstracts<br>A compilation of approximately 320 technical abstracts dealing with air pollution aspects municipal incineration is presented in this bibliography. The abstracts relate to the following categories: emission sources, control methods, measurement methods, air quality measurements, basic science and technology, effects-human health, effects-plants and livestock, effects - materials, effects - economic standards and criteria, legal and administrative, and social aspects. |                        |                                                  |                                      |
| 17. Key Words and Document Analysis. 17a. Descriptors<br>Incinerators<br>Combustion gases<br>Air pollution<br>Bibliographies                                                                                                                                                                                                                                                                                                                                                                             |                        |                                                  |                                      |
| 17b. Identifiers/Open-Ended Terms<br>Municipal incineration                                                                                                                                                                                                                                                                                                                                                                                                                                              |                        |                                                  |                                      |
| 17c. COSATI Field/Group 13B, 21H                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                                                  |                                      |
| 18. Availability Statement<br>EP4.9:92 SOD Catalogue Number: Available from<br>Superintendent of Documents, Washington D C 20402.<br>SOD 5503-0005                                                                                                                                                                                                                                                                                                                                                       |                        | 19. Security Class (This Report)<br>UNCLASSIFIED | 21. No. of Pages<br>91               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                        | 20. Security Class (This Page)<br>UNCLASSIFIED   | 22. Price<br>1.00                    |



## **BIBLIOGRAPHIES IN THIS SERIES**

- AP-92, Air Pollution Aspects of Emission Sources:**  
**Municipal Incineration – A Bibliography with Abstracts**
- AP-93, Air Pollution Aspects of Emission Sources:**  
**Nitric Acid Manufacturing – A Bibliography with Abstracts**
- AP-94, Air Pollution Aspects of Emission Sources:**  
**Sulfuric Acid Manufacturing – A Bibliography with Abstracts**
- AP-95, Air Pollution Aspects of Emission Sources:**  
**Cement Manufacturing – A Bibliography with Abstracts**
- AP-96, Air Pollution Aspects of Emission Sources:**  
**Electric Power Production – A Bibliography with Abstracts**

**AIR POLLUTION ASPECTS  
OF EMISSION SOURCES:  
MUNICIPAL INCINERATION—  
A BIBLIOGRAPHY WITH ABSTRACTS**

Office of Technical Information and Publications  
Air Pollution Technical Information Center

ENVIRONMENTAL PROTECTION AGENCY  
Air Pollution Control Office  
Research Triangle Park, North Carolina  
May 1971

---

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price \$1.00  
Stock Number 5503-0005

The AP series of reports is issued by the Air Pollution Control Office to report the results of scientific and engineering studies, and information of general interest in the field of air pollution. Information reported in this series includes coverage of APCO intramural activities and of cooperative studies conducted in conjunction with state and local agencies, research institutes, and industrial organizations. Copies of AP reports are available free of charge to APCO staff members, current contractors and grantees, and nonprofit organizations - as supplies permit - from the Office of Technical Information and Publications, Air Pollution Control Office, Environmental Protection Agency, P.O. Box 12055, Research Triangle Park, North Carolina 27709. Others may obtain copies from the Government Printing Office.

Air Pollution Control Office Publication AP-92



## CONTENTS

|                                             |     |
|---------------------------------------------|-----|
| INTRODUCTION . . . . .                      | vii |
| ANNOTATED BIBLIOGRAPHY                      |     |
| A. Emission Sources . . . . .               | 1   |
| B. Control Methods . . . . .                | 31  |
| C. Measurement Methods . . . . .            | 56  |
| D. Air Quality Measurements . . . . .       | 61  |
| E. Atmospheric Interaction (None)           |     |
| F. Basic Science and Technology . . . . .   | 63  |
| G. Effects - Human Health . . . . .         | 64  |
| H. Effects - Plants and Livestock . . . . . | 65  |
| I. Effects - Materials . . . . .            | 66  |
| J. Effects - Economic . . . . .             | 67  |
| K. Standards and Criteria. . . . .          | 68  |
| L. Legal and Administrative . . . . .       | 70  |
| M. Social Aspects . . . . .                 | 76  |
| N. General . . . . .                        | 78  |
| AUTHOR INDEX . . . . .                      | 79  |
| SUBJECT INDEX . . . . .                     | 83  |

# **AIR POLLUTION ASPECTS OF EMISSION SOURCES: MUNICIPAL INCINERATION— A BIBLIOGRAPHY WITH ABSTRACTS**

## **INTRODUCTION**

Municipal incineration contributes significantly to the overall air pollution level in the United States. To aid efforts to improve air quality, the Air Pollution Technical Information Center (APTIC) of the Office of Technical Information and Publications, Air Pollution Control Office, has compiled this bibliography relevant to the problem and its solution.

Approximately 320 abstracts have been selectively screened from the contents of APTIC's information storage and retrieval system to cover the 14 categories set forth in the table of contents. The compilation is intended to be representative of available literature, and no claim is made to all-inclusiveness.

Subject and author indexes refer to the abstracts by category letter and APTIC accession number. Generally, higher accession numbers, representing the latest acquisitions, cover the most recent material.

All documents abstracted herein are currently on file at the Air Pollution Technical Information Center, Air Pollution Control Office, Environmental Protection Agency, P. O. Box 12055, Research Triangle Park, North Carolina 27709. Readers outside the Environmental Protection Agency may seek duplicates of documents directly from libraries, publishers, or authors.

## A. EMISSION SOURCES

00027

A. H. Rose, Jr., M. Corn, R. R. Horsley, D. R. Allen, and P. W. Kolp

**AIR POLLUTION EFFECTS OF INCINERATOR FIRING PRACTICES AND COMBUSTION AIR DISTRIBUTION.** *J. Air Pollution Control Assoc.* 8(4):297-309, Feb. 1959.

The relationships between incinerator design criteria and resulting atmospheric contaminant discharges were investigated. Tests were made by burning a fuel of constant composition in a prototype, multiple-chamber incinerator under controlled conditions. Effects of variables were measured by analyzing the flue gases for solids, hydrocarbons, oxides of nitrogen, and CO. The series of tests reported was made to (1) provide information on the relative importance of such variables as stoking and amount of fuel per charge insofar as they affect the production of atmospheric pollutants, and (2) evaluate the chosen levels of variables such as excess combustion air, underfire and secondary air distribution, and fuel charging rate. Production of particulates was highly dependent on the amount of excess combustion air and the percentage of this air entering under the fuel bed. At the 50% excess air level, particulate discharge increased when underfire air was increased from 15% to 30% of the total combustion air. This did not hold true for the 150% excess air level. Reduction of hydrocarbons and CO appeared to be more dependent on the level of excess combustion air available than on its distribution between overfire, underfire, and secondary air. These pollutants were produced under combustion with 50% excess air but not with 150% excess. Production of oxides of nitrogen depended on the rate of fuel charging, the amount of excess air, and the gas temperature in the ignition zone. (Author)

00673

H.H. Hovey, A. Wisman, J.F. Cunnans

**THE DEVELOPMENT OF AIR CONTAMINANT EMISSION TABLES FOR NONPROCESS EMISSIONS** *J. Air Pollution Control Assoc.* Vol. 16(7):362-366, July 1966. (Presented at the 58th Annual Meeting, Air Pollution Control Association, Toronto, Canada, June 20-24, 1965, Paper No. 65-17.)

In New York State, the calculation of air contaminant emissions from a variety of sources is an essential part of comprehensive air pollution studies. The tables used to calculate emissions were obtained from an extensive literature search and modified to apply to New York State conditions. For example, sulfur dioxide emission factors for coal were selected to reflect the average sulfur content of the coal sold in New York State. Since the literature contains a wide array of emission factors,

00712

M. Wolf J.W. Jacobi

**REFUSE BURNING. (MULLVERBRENNUNG.)** *Brennstoff-Waerme-Kraft (Dusseldorf)* 18(4):169-170, Apr. 1966.

This is an annotated bibliography on refuse burning. Fifty-seven references cover technical problems and processes,

description of plants already built, new plants either being built or planned and the current state of the art in other countries of Europe and the U.S.A. Subjects treated include chlorine corrosion in refuse fires, waste burning with and without heat utilization and combinations of composting and burning. New plants in various cities in Germany with capacities of up to 360 tons per day are planned; one in Nurnberg will produce 27-34 tons per hour of steam.

00943

F. Z. Rohrman and J. H. Ludwig

**SOURCES OF SULFUR DIOXIDE POLLUTION.** *Chem. Eng. Prog.*, 61(9):59-63, Sept. 1965. (Presented at the 55th National Meeting, American Inst. of Chemical Engineers, Houston, Tex., Feb. 7-11, 1965.)

Authors discuss the sources of sulfur pollution and depict their results in charts (good analysis). The major areas covered are: coal combustion; coke; generation of electricity; refinery operations; ore smelters and roasters' sulfuric acid manufacture; refuse incineration; and coal refuse banks.

00972

M. Mayer

**A COMPILATION OF AIR POLLUTANT EMISSION FACTORS FOR COMBUSTION PROCESSES, GASOLINE EVAPORATION, AND SELECTED INDUSTRIAL PROCESSES.** Public Health Service, Cincinnati, Ohio, Div. of Air Pollution, May 1965, 53 p.

The source emission factors presented in this report were compiled primarily for use in conducting an air pollutant emission inventory. The compilation is the result of an extensive literature survey and includes emission factors for the principal combustion and industrial processes. Obviously, the best emission factor to use for any specific source of air pollution is that resulting from source tests of the specific source. Unfortunately, many urban areas are not equipped to conduct the numerous and expensive stack testing studies needed for an emission inventory. The purpose of this compilation of emission factors is to provide the best available substitute to air pollution control agencies unable to conduct extensive source test programs. In certain cases, particularly in the combustion and refuse disposal areas, a single number is presented for the emission factor for a specific pollutant. It should be understood that the number is usually a weighted average of several different values found in the listed references. The compilation of source emission factors presented is, in our judgment, the most accurate currently available. As new technical advances are made, however, and additional emission data become available in the literature, the present compilation should be revised to reflect the newer data and developments.

01788

R.P. Hangebrauck, D.J. Von Lehmden, J.E. Meeker

**EMISSIONS OF POLYNUCLEAR HYDROCARBONS AND POLLUTANTS FROM HEAT-GENERATION AND INCINERATION PROCESSES.** J. Air Pollution Control Assoc. 14, (7) 267-78, July 1964. (Presented at the 56th Annual Meeting, Air Pollution Control Association, Detroit, Mich., June 11, 1963.)

This paper presents emission data from a series of tests, for which the sources tested included typical combustion processes involving the burning of conventional fuels (coal, oil, and gas) and of certain commercial and municipal solid wastes. In addition to obtaining over-all emission data from different sizes and types of combustion units, a primary objective of the study was to establish the relative importance of various combustion processes as contributors of benzo(a)pyrene (3,4 benzpyrene) and other polynuclear hydrocarbons with demonstrated or potential carcinogenic properties. The other pollutants measured included particulate matter, carbon monoxide, total gaseous hydrocarbons, oxides of nitrogen, oxides of sulfur, and formaldehyde. Two categories of combustion sources were tested. Those burning conventional fuels were designated as heat-generation processes, and those burning waste materials were classed as incineration processes. Design and operation data for the units studied are given in tables.

02009

N.S. Iversen

**DISTRICT HEATING AND INCINERATION IN A DANISH TOWN; THEIR ROLE IN REDUCING AIR POLLUTION.** Proc. (Part I) Intern. Clean Air Cong., London, 1966. (Paper III/11). pp. 71-2.

Between 350 and 400 Danish towns are district heated. The towns in question have a population of between 1 1/2-2 million people. In the district heated towns the SO<sub>2</sub> contents in the air has been reduced by approximately 50 per cent, and the amount of soot and ash pumped into the air has also been reduced by approximately 50 per cent. This is of course compared to a town community without district heating. Beside the advantages of clean air the district heated towns are supplied with cheap and abundant heat. (Author abstract)

02334

**APARTMENT HOUSE INCINERATORS (FLUE-FED).** National Academy of Sciences-National Research Council, Washington, D.C., Building Research Advisory Board 44, 1965. (Publication No. 1280) (Rept. No. 29 to the Federal Housing Administration).

This report deals primarily with flue-fed incinerators, however, the performance levels and test methods recommended are applicable to any apartment house incinerator. Detailed design criteria such as combustion chamber geometry, material usage, and accessories were not part of the study. Performance levels and test methods are presented, to permit selection of flue-fed incinerators in a manner that takes into account present air pollution problems.

02414

T.E. Kreicheit

**AIR POLLUTION ASPECTS OF TEPEE BURNERS USED FOR DISPOSAL OF MUNICIPAL REFUSE.** Public Health Service, Cincinnati, Ohio, Div. of Air Pollution. (999-AP-28) Sept. 1966. 39 pp.

This report covers an evaluation study of air pollution emissions based upon an extensive literature search and field trips to 15 tepee burners in six states. Smoke as a function of composition and rate of charge was observed, and the effect of burner charging methods, construction, and operational procedures on smoke emissions recorded. None of the tepee incinerators observed in operation meet normal visible emission limitations of air pollution control ordinances of most municipalities. Nuisance problems from fly-ash fallout can be expected within distances of up to 1,290 feet downwind from an operating tepee. (Author abstract)

02773

E.M. Voelker

**CONTROL OF AIR POLLUTION FROM INDUSTRIAL AND HOUSEHOLD INCINERATORS.** Proc. Natl. Conf. Air Pollution, 3rd, Washington, D.C., 1966. pp. 332-8.

A properly proportioned multiple chamber incinerator can with reasonably good operating and maintenance care be operated without creating a nuisance. Air pollution codes should not be made so restrictive as to make 'on-the-site' incineration uneconomical for the owner, because incineration offers much more to a community or area than a solution to only one phase of the refuse disposal problem. However, much work remains to be done in the control of particulate matter (fly ash and dust) from incinerators and in determining how to properly and accurately measure these emissions. It is recommended that the nomenclature and permissible performance criteria be expressed in uniform terms acceptable to all controlling authorities.

03154

N. E. Flynn and W. R. Crouse

**REPORT ON NITROGEN OXIDES IN THE BAY AREA AIR POLLUTION CONTROL DISTRICT.** Preprint. 1964.

Total oxides of nitrogen (NO<sub>x</sub>) emissions in the Bay Area Air Pollution Control District for 1963 are estimated at 515 tons/day. A summation of emissions of oxides of nitrogen by general source categories is presented. Transportation at 323 tons/day is the major source category of nitrogen oxides emissions and accounts for 63% of all oxides of nitrogen emissions for the Bay Area. Combustion operations at 150 tons/day are the second largest source category and contribute 29% of the nitrogen oxides emissions. Emissions from small, medium, and large stationary sources with incinerations, agriculture, and transportation sources grouped separately, are presented. (Author summary modified)

03155

J. I. Frankel

**INCINERATION OF PROCESS WASTES.** Chem. Eng. 73(18):91-96, Aug. 29, 1966.

Wastes are disposed of in furnaces, rotary kilns, fluidized beds and other types of incinerators, depending on whether their form is solid, liquid, gaseous or slurry. How these incinerators work is described and their advantages are discussed. (Author abstract)

03868

W. Fichtner, K. G. Maurer, H. Muller

**THE STUTTGART REFUSE INCINERATION PLANT: LAYOUT AND OPERATION EXPERIENCE.** Preprint. (Presented at the Winter Annual Meeting and Energy Systems Exposition, American Society of Mechanical Engineers, New York City, Nov. 27-Dec. 1, 1966.)



After almost three years of construction the Stuttgart refuse incineration plant was placed in operation on June 2, 1965. This plant was incorporated into the existing Power Plant Munster of the Technische Werke of the City of Stuttgart. The Plant was erected by the Technische Werke, for which the authors' company had been retained as Consulting Engineers. This firm prepared the plans in cooperation with the Planning Department of the Technische Werke Stuttgart. The heat generated by the incineration of refuse is utilized for steam production by boilers having 220,000/275,000 lb per hr capacity with combined oil/refuse firing system. The size of the boilers was governed by the requirements of the district heating system which is part of the Power Plant Munster. The purpose of this paper is to report the operating results so far experienced and to describe the mechanical design features of the plant. (Author abstract)

03870

C. A. Hescheles

**INDUSTRIAL WASTE ANALYSIS AND BOILER PERFORMANCE TEST BURNING WASTES.** Preprint. (Presented at the Winter Annual Meeting and Energy Systems Exposition, American Society of Mechanical Engineers, New York City, Nov. 27-Dec. 1, 1966.)

Detailed analyses are presented of industrial process wastes from the normal manufacturing process in the rubber goods industry. Test results are presented from a boiler burning industrial process wastes, manually batch fed to a reciprocating stoker. The boiler is equipped with a water cooled furnace specially designed for high furnace temperatures. (Author abstract modified)

05005

R. P. Hangebrauck, D. J. von Lehmden, and J. E. Meeker

**SOURCES OF POLYNUCLEAR HYDROCARBONS IN THE ATMOSPHERE.** Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control. (PHS Publ. No. 999-AP-33.) 1967. 48 pp.

Rates of emissions of polynuclear hydrocarbons were measured at several sources considered likely to produce such emissions. The sources included heat generation by combustion of coal, oil, and gas; refuse burning; industrial processes; and motor vehicles. The annual emissions of benzo(a)pyrene in the United States were estimated for each of the sources surveyed, to provide a rough gauge of the importance of each source. Small, inefficient residential coal-fired furnaces appear to be a prime source of polynuclear hydrocarbons; other sources may be of local importance. Production of polynuclear hydrocarbons was generally associated with conditions of incomplete combustion. (Author abstract)

05160

J. L. Mills, K. D. Leudtke, P. F. Woolrich, and L. B. Perry

**EMISSIONS OF OXIDES OF NITROGEN FROM STATIONARY SOURCES IN LOS ANGELES COUNTY (REPORT 3: OXIDES OF NITROGEN EMITTED BY MEDIUM AND LARGE SOURCES).** Los Angeles County Air Pollution Control District, Calif. (Apr. 1961). 61 pp.

The total weight of oxides of nitrogen discharged into the atmosphere each day in Los Angeles County from stationary sources was determined. The sources are divided into medium and large sources. Medium sources includes those emitting five to one hundred lbs. NO<sub>x</sub> per hr. and the large sources includes those emitting over 100 lbs. per hr. The total emissions of NO<sub>x</sub> from all medium sources amounts to 70 tons per day

during the winter and 54 tons per day during the summer. The total emissions of NO<sub>x</sub> from all large sources amounts to 160 tons per day during the winter and 93 tons per day during the summer.

05465

Weintraub, M., Orning, A., and Schwartz, C.

**EXPERIMENTAL STUDIES OF INCINERATION IN A CYLINDRICAL COMBUSTION CHAMBER.** Bureau of Mines, Washington, D.C. (Report of Investigations 6908.) 1967. 44 pp.

An incinerator utilizing the principle of tangential overfire air in a single cylindrical combustion chamber is effective in the destruction of combustible wastes with the emission of clean and innocuous gases. There was a correlation between the burning rate, air rate, chamber diameter, and inlet port diameter. In the combustion of moist refuse, the evaporation of the water proceeded through the fuel bed as a wave, with an ignition wave following the evaporation. Combustibles of high moisture content burned in a refractory-lined chamber with greater excess of air than drier combustibles burned in an unlined chamber of the same dimensions.

05492

E. R. Kaiser

**COMPOSITION AND COMBUSTION OF REFUSE.** Proc. MECAR Symp., Incineration of Solid Wastes, New York City, 1967. pp. 1-9

Three lots of 3/4 to 1 ton each of refuse from the pits of the Oceanside (Long Island, N.Y.) Refuse Disposal Plant were sorted by components. The findings are tabulated. Chemical analyses, heating values, combustion air, physical features, and combustion products are covered. Incineration of municipal refuse reduces the weight of refuse by 75 to 80%, and the volume of land space required by 90 to 93%. The gaseous products of combustion are natural constituents of the atmosphere. The sulfur dioxide emission is low because of the low sulfur content of refuse and the conversion of most of the sulfur to sulfates by the alkaline ash. The control of particulate matter to acceptable limits can be accomplished with known means. Because of the large tonnages available, the negative cost of refuse, the calorific values, and low sulfur dioxide emission, refuse should be considered as a suitable fuel for power generation.

05493

H. C. Moore

**REFUSE FIRED STEAM GENERATOR AT NAVY BASE, NORFOLK, VA.** Proc. MECAR Symp. Incineration of Solid Wastes, New York City, 1967. pp. 10-21.

The utilization of waste heat from municipal incinerators has been an important consideration in the minds of economy-minded engineers for some years. Earlier, batch feed installations with waste heat boilers have produced from 1 to 2 lb. of steam maximum per pound of refuse. Recent improvements in furnace design, continuous feeding of refuse and removal of residue have resulted in more constant furnace temperatures which should result in more efficient steam production. It must be realized that not all municipal installations economically justify maximum steam production, especially smaller plants and many larger plants not operating 24 hr a day. Many plants have no market for steam. This design is an attempt to obtain the maximum steam production from waste heat by applying to a refuse burning plant some modern design features that are new in this application. Calculations indicate that it is logical to expect at least 50% greater steam production than in

## MUNICIPAL INCINERATORS

earlier installations in this country. It is reasonable to expect that the experience with design will lead to still further advances in the design and operation of refuse incinerators with maximum steam producing capability. Design considerations, economic considerations, specification details, steam production and the equipment and layout are considered.

05494

Stabenow, G.

**NEW INCINERATOR AT MUNICH, WEST GERMANY.** Proc. Mecar Symp., Incineration of Solid Wastes, New York City, 1967. pp. 22-33.

The City of Munich utilizes the heat from burning refuse to generate electric power in a most modern power generating station. The power generation in this plant was started in 1964, and the incinerator plant and the experience gained from its operation during the past 2 1/2 years, is described. The imagination of the engineers and designers for the City of Munich have shown a lot of foresight as well as pioneering spirit to embark on such a remarkable venture to solve the City's refuse problem. It sounds unbelievable, but the energy of the refuse picked up from your home on Friday may come back to light the lamps of your home the following day. There is no reason why the same energy utilization cannot be applied in this country, especially as we have considerably greater quantities of refuse available with even higher heating values than presently found in Europe. Paris has just embarked on construction of their new Ivry II power plant where 2640 tons of refuse per day will be burned on two Martin grates at an hourly rate of 55 tons per incinerator grate. These units will be the largest of their type in the world. The Martin Grate, the stream generator, and the plant designs for Phases I, II, and III are described. Operating costs for Phases I and II are appended.

05495

L. S. Wegman

**AN INCINERATOR WITH REFRACTORY FURNACES AND ADVANCED STACK GAS CLEANING SYSTEMS.** Proc. MECAR Symp., Incineration of Solid Wastes, New York City, 1967. pp. 34-42.

The Town of North Hempstead's incinerator has more equipment in it to remove the polluting material from the stack gases than any other plant known, and it has space to receive more if the Town wishes to install it. The plant contains three furnaces, constructed by Morse Boulger and rated at 200 tons per 24 hours each. Two have Flynn & Emrich Constant Flo stokers and one has an Illinois stoker. The latter is particularly good for burning large items such as sofas, for it can be operated dependably at extremely slow speeds, and these items are usually fed into this furnace. But in general, all three furnaces burn the same material. Each of the two receiving bins and unloading areas can accommodate six trucks simultaneously, and the total water level bin capacity exceeds 200% of the plant capacity. Two P & H cranes, rated at 3 1/2 tons and equipped with 2 1/2 yard Blaw Knox grapples, transfer refuse from the bins to the furnace loading chutes. Either crane can service both bins. Basic design data for each furnace follows: Effective grate area--267 sq. ft. or 62.4 lbs per hour per sq. ft. of grate. Heat release-- 306,000 Btu per sq. ft. per hr; Furnace volume--5,300 cu ft. measured from the grate surface to underside of the roof refractory, or 26.5 cu ft. per ton of rated capacity; Unit flue and secondary combustion area between the furnace and settling chamber--3,200 cu ft, and Settling and expansion chamber with set bottom--7,200 cu ft. After leaving the settling and expansion chamber the gases

pass through a spray chamber, air cooling chamber, cyclones, induced draft fan and a large flue before reaching the stack. The stack extends 265 ft. into the air to help the effluent gases pierce the prevailing meteorological ceiling for dispersion and atmospheric dilution. For practical reasons, the control loops were color-coded. The first three control furnace operation while the last three coordinate the functions of the various air pollution control systems as follows: The instrumentation, fail-safe damper, furnace wall construction, and the two water systems are described.

05497

Hescheles, C. A.

**BURNING INDUSTRIAL WASTES.** Proc. Mecar Symp., Incineration of Solid Wastes, New York City, 1967. pp. 60-74.

Furnace selection and design, the necessity of an adequate survey and waste analysis, waste heat recovery, and a central facility to burn all solid and liquid wastes are reviewed. A summary of industrial waste analysis in the rubber industry is tabulated.

05520

R. E. Williams

**INCINERATION PRACTICE AND DESIGN STANDARDS.** Proc. Clean Air Conf., Univ. New South Wales, 1962, Paper 27, Vol. 2, 26 p.

A discussion of the practice and design standards required for efficient incineration of domestic refuse is presented. It is agreed by combustion engineering furnace design authorities that multiple chamber incineration combines the best means of disposing of combustible refuse at the source with a minimum emission of air contaminants. Furnace manufacturers have found that construction of multiple chamber incinerators of designs that comply with air pollution control regulations is only slightly more difficult or expensive than equivalent construction of industrial incinerators of earlier design. (Author conclusions modified)

05651

**A LOW FLUE TEMPERATURE INCINERATOR.** Am. Gas Assoc. Monthly 49 (3), 18-9 (Mar. 1967.)

Methods for achieving low flue gas temperatures with contemporary domestic gas-fired incinerators to provide for their installation in dwellings not equipped with a chimney are reviewed. These methods include the use of power venting, or an added-on water spray device installed in the flue.

05718

Public Health Service, Durham, N. C., National Center for Air Pollution Control

**SPECIFICATIONS FOR INCINERATOR TESTING AT FEDERAL FACILITIES.** ((34))p., Oct. 1967. 3 refs.

Test procedures are recommended for use in determining whether an incinerator meets the air pollution emission standards of the Federal Code as detailed herein. These test procedures are applicable to the following types of incinerators: (1) Multiple chamber incinerators burning less than 2,000 pounds per hour of general refuse; (2) Multiple chamber incinerators burning pathological waste; and (3) Single-chamber incinerators, except flue or chute fed incinerators, burning either general refuse or pathological waste. The procedures may be used where scrubbers or afterburners are employed. To minimize the effects of type of waste, charging, and stoking processes, standard procedures have been adopted. Test



methods were incorporated in these procedures. Equivalent test procedures or equipment may be used for purposes of determining compliance, provided that they are approved by the Federal Facilities Section, Abatement Program, National Center for Air Pollution Control, Washington, D. C.

05815

C. G. Segeler

**THE GAS INDUSTRY AND ITS CONTRIBUTION TO AIR POLLUTION CONTROL.** Preprint. (Presented at the 54th Annual Meeting, Air Pollution Control Association, New York City, June 11-15, 1961.)

Two facts are demonstrated here: first that the use of natural gas produced negligible air pollution if any; and second that natural gas is available under such economic conditions that its use will expand. Beginning with the first fact, the constituents of natural gas are discussed. A trace constituent of primary concern in utility delivered gas (97% natural gas) is sulfur which is the result of an odorant added for the detection of gas. Sulfur is present at a concentration of approximately six parts per million. Total sulfur in the combustion products of a million lbs. of natural gas amounts to only 37 lbs. The formation of NO at high flame temperatures and its subsequent oxidation to NO<sub>2</sub> at lower temperatures is not an intrinsic fuel property but is influenced by the conditions of combustion. Values for residential, industrial and commercial production of nitrogen oxides by combustion of natural gas are given, based on utility company gas distribution. Information on emission of nitrogen oxides vehicles is given as a frame of reference. Application of laboratory investigations of emissions from equipment and their interpretation are discussed. A proposed plan for improving industrial safety using group organization with annual inventories and reports is discussed. The following specialized application of gas in air pollution control are discussed: (1) domestic incineration, (2) destroilet, (3) flue fed apartment incinerators, (4) industrial boiler plants, and (5) commercial and industrial incinerators. Application in smoke control by reclaiming operations, research on an appliance for consuming kitchen grease vapors; and catalytic fume oxidation systems are discussed. As for the availability of natural gas, a brief survey of its consumption and reserve statistics is presented.

05877

R. Goder

**BIBLIOGRAPHY ON INCINERATION ON REFUSE.** J. Air Pollution Control Assoc. 12 (7), 334-8 (July 1962).

A bibliography on incineration of refuse presents 276 references.

05878

R. Tanner

**THE NEW REFUSE INCINERATOR OF L. VON ROLL A.-G.** J. Air Pollution Control Assoc. 12 (6), 285-90 (June 1962)

The first and most important requirement is hygiene, the second is economy. Repairs and maintenance with respect to plant efficiency are of greater importance than in the conventional power plant. One must realize that in incinerator plants to effect pronounced waste heat utilization, the ideal solution cannot simply be taken from the design of modern steam generating plants. It is not advisable to use induced draft for incineration plants as no fan can stand up for any length of time under the dust laden and corrosive flue gases. Natural draft, on the other hand, requires a high chimney that must be lined for the relatively high gas temperatures. Also, a boiler

should be used that offers the least possible resistance to the gas flow. For this reason, economizers are not appropriate. The entire heating surface must be located in the boiler which, therefore, becomes very large and can only be exerted with moderation. There is no necessity of providing a highly efficient boiler. To the contrary, the simplest, cheapest boiler is the best in this case. This applies also to the steam situation as the omission of an economizer and the comparatively low flue gas entrance temperature are the limiting factors here. The flue gas temperature is limited by the heating value of the refuse and the melting point of the ashes and cannot be increased much over 1000 C (1832F). Therefore, it seems the construction of a waste heat boiler for a pressure of about 40 Btu (587.84 lb/sq in.), and a temperature of 400 C (752 F) would be the limit of an economical recommendation. Closer examination namely shows that a further raising of pressure and temperature of the steam does not offer any more advantages in a given case. Cleaning the flue gases is of prime importance. Cyclones and electrostatic filters are provided, therefore. A nuisance caused by dust in the neighborhood is thereby avoided.

05969

B. Beorse, P. Kurtz, J. Mizushima, R. D. Chipman, and A. F. Bush

**INCINERATION STUDIES: A STUDY OF AIR POLLUTION CONTROL ASPECTS OF REFUSE INCINERATION.** (In: First report of air pollution studies.) ((California Univ., Los Angeles, Dept. of Engineering,)) (Rept. No. 55-27.) (July 1955). 68 pp.

In the field, tests have been made on existing equipment. In the laboratory, model incinerators and fundamental combustion principles have been investigated. In the library and office, reaction rates and analytical computations of design parameters have been studied, and plans for a pilot plant test facility have been developed. An investigation of particulate material discharged from incinerators and other combustion processes such as automotive engines, oil burning steam boiler, natural gas burner, etc., have been carried on in an effort to evaluate their emissions to the air on a particle count and size frequency basis. The results to date indicate that there are similarities between municipal, household and laboratory burning operations which gives some assurance that the information obtained from laboratory tests will be applicable to large scale units, and should aid in the study of possible ways to improve incinerators. The application of reaction rate equations to certain chemical reactions which take place in burning refuse will aid in determinations of combustion chamber size and in general will be a valuable aid to design. A method of smoke measurement using an electron microscope has been employed. No direct correlations are apparent between these measurements and the usual measurements for smoke opacity and weight of flyash. However, on a 'clear' day the concentration is about  $0.06 \times 10$  to the 9th power particles/cu ft., while on a 'smoggy' day the concentration is about  $0.70 \times 10$  to the 9th power particles/cu ft. From preliminary studies of particle counts on various types of fuel burning operations it has been shown that some fuels produce greater quantities of particulate material than others. The calculated numbers of particles released from all types of fuel burned in Los Angeles County can account for the difference in particulate count measured on a 'clear' day and a 'smoggy' day.

06086

R. L. Stenborg, R. R. Horsley, R. A. Herrick, A. H. Rose, Jr.  
**EFFECTS OF DESIGN AND FUEL MOISTURE ON INCINERATOR EFFLUENTS.** *J. Air Pollution Control Assoc.* 10 (2), 114u20 (Apr. 1960). (Presented at the 52nd Annual Meeting, Air Pollution Control Association, Los Angeles, Calif., June 21-26, 1959.)

Tests were made to determine the effects of fuel moisture content on pollutant emissions from an experimental incinerator of fixed dimensions while varying (1) the amount and distribution of combustion air, and (2) the burning rate as measured by the amount of fuel charged per hour. Overfire combustion air was introduced into the front of the ignition chamber at the grate level, and swept the surface of the burning fuel bed. Underfire air entered through the ash pit and passed up through the fuel bed. Secondary air was introduced through a duct built into the top of the bridge-wall and was discharged through a series of ports opening into the top of the mixing chamber. Dry components of the fuel include equal parts, by weight, of newspaper and corrugated cardboard, mixed in a ratio of three to one with wood chips. Chopped potatoes were substituted for leafy vegetables as the wet component because of their year-round availability. Five-pound charges were prepared with the wet-to-dry components adjusted to provide a fuel with an average moisture content of either 25 or 50%. Particulate, oxides of nitrogen, hydrocarbons, carbon monoxide, and smoke were measured. Because of the basic physical and chemical laws involved, factors demonstrated by this study as affecting the increase or decrease of air pollutants should be the same as those affecting production of pollutants from larger scale incinerators.

06370

Richard W. Boubel, Kenneth R. Wise

**AN EMISSION SAMPLING PROBE INSTALLED, OPERATED, AND RETRIEVED FROM GROUND LEVEL.** *J. Air Pollution Control Assoc.*, 18(2):84-85, Feb. 1968. 3 refs. (Presented at the 60th Annual Meeting, Air Pollution Control Association, Cleveland, Ohio, June 11-16, 1967, Paper 67-118.)

The 'Wigwam' type wood residue incinerator, similar to many other sources, requires sampling at the point where the emissions enter the atmosphere. Because the location of the emission point is hazardous and unpleasant for the operation of a sampling probe, a portable, tilt-up column was developed which permitted installation, operation and retrieval of the sampling train from ground level. The sampling train developed permitted determination of the size distribution and weight of the particulate emitted by this highly variable source. Representative emission collections are presented and discussed. (Authors' abstract)

06852

N. B. Hume

**HISTORY OF EFFORTS AT INCINERATION IN THE LOS ANGELES AREA.** *J. Air Pollution Control Assoc.* 17 (5), 308-9 (May 1967).

The history of incineration in Los Angeles from 1943 to the present is reviewed as representative of all southern California areas. Today, of the more than a dozen municipal incinerators in operation prior to 1960, there is only one in regular operation in the greater Los Angeles area.

06937

Bender, R. J.

**INCINERATION PLANT - PLUS.** *Power*, 111(1):62-64, Jan. 1967.

The world's largest incinerator of household refuse is described. Located at Issy-les-Moulineaux, a suburb of Paris, it operates 24 hours a day. Its normal capacity is 400,000 tons a year which can be pushed to 1/2 million, nearly 57 tons an hour. The heat is used to generate steam at a pressure of 928 psi and a temperature of 770 F. In winter it is used for city heating at a pressure of 290 psi. In summer it generates 15,000 kw of electricity in addition to the 9000 kw generated all year round. Air pollution is practically nil because of the efficient operation of the electrostatic precipitators. The inlet to the primary air fans is designed to draw air from above the silos to remove any dust or odor caused by the discharging trucks on the platform.

07206T

Brancato, Biagio

**THE INCINERATION OF URBAN SOLID REFUSE IN THE MILAN PLANT.** ((Incenerimento dei rifiuti solidi urbani nell'impianto di Milano.)) *Fumi Foiveri (Milan)*, 7(4):70-78, April 1967. 8 refs.

The plant consists of a pit where refuse is placed, a bridging van to feed the furnace, a furnace, heaters, filters, a chimney, water purifiers, a central station for electricity, and heat exchangers. The composition of solid refuse varies according to locale. The elementary composition of the Milanese refuse is C-56%, H2-5%, O2-36%, and N2-3%. The Milan plant burns up to 600 tons/day, and the heat produced is harnessed to produce electrical energy by means of a 9200 kVA generator. The hot vapor products could be used for industrial heating. The smoke particles are removed by the use of suitable electrostatic precipitators. The water is purified in a cement basin under the cooling system. flocculation apparatus in this basin purifies the water by means of chemical reagents. The cost of the plant is 5.8 million Italian lire per day. The cost per ton is between 1460 and 1340 lire which is less than the 1550 lire it costs to operate other plants.

07561

Kaiser, E. R., J. Halitsky, M. B. Jacobs, and L. C. McCabe

**PERFORMANCE OF A FLUE-FED INCINERATOR.** *J. Air Pollution Control Assoc.*, 9(2):85-91, Aug. 1959. 7 refs. (Presented at the 51st Annual Meeting, Air Pollution Control Assoc., Philadelphia, Pa., May 25-28, 1958.)

A limited survey of representative modes of operation and results of one flue-fed incinerator is reported. The tests were conducted to serve as a basis for comparison with future tests on identical incinerators with modifications to improve combustion and reduce air pollution. The incinerated refuse from a 128-apartment building was approximately 430 lb. a day. The flue-fed incinerator reduced the apartment refuse to about 37% of its original weight and to about 10% of its original volume. The bulk density of the refuse averaged 4.1 lb/cu ft. in the incinerator. The residue had a bulk density of 15.4 lb/cu ft. in the ash cans. The residue averaged 64% metal and glass, 12% ash, 16% combustible, and 8% moisture, excluding quench water. The air normally supplied to the furnace was 10 to 20 times the theoretical air necessary for complete combustion. The high excess air reduced the furnace temperatures and undoubtedly affected adversely the combustion of volatile matter and emission of fly ash. The infiltration air entering the flue through vents on the service doors and cracks averaged 35%



more than entered the furnace. Sealing the vents reduced the infiltration air to the flue to 45% of the furnace air during the period of fast burning. The peak furnace temperatures varied from 970 to 1200 deg F. The emissions of particulate matter to the atmosphere via the flue gases ranged from 0.85 to 1.55% of the refuse weight. The weights of particulate matter ranged from 2.5 to 4.7 lb/1000 lb of furnace gas corrected to 12% CO<sub>2</sub>. The emission of eight noxious gases totaled 0.9 to 3.0 lb/100 lb refuse. The presence of additional unburned hydrocarbons in the flue gases was confirmed by mass-spectrometer tests. The average odor concentrations ranged from 2.5 to 100 ASTM odor units. The incinerator had inherent features of design and operation that caused high emissions of particulate matter and unburned organic compounds. The charging of refuse during burning could contribute to the discharge of particulate matter. Suggested modifications to the conventional incinerator include control of the furnace air supply, better mixing of air and volatile products from the burning refuse in a zone of high temperature, new furnace designs to eliminate the necessity for hooking and raking the refuse and residue, and residue removal with minimum air flow.

07659

Balden, A. R.

**ULTIMATE DISPOSAL OF CONCENTRATED WASTE BY INCINERATION.** In: Proceedings of the 21st Industrial Waste Conference May 3, 4, and 5, 1966, Part One, Lafayette, Ind., Purdue Univ., Jan. 1967, p. 581-590. 2 refs.

The waste materials requiring ultimate disposal which are of most general concern to an automotive corporation are: (1) oily scum resulting from the treatment of wastewater from machining plants; and (2) water base paints and acrylic enamel waste solids from assembly plants. The procedures by which pollutants are removed from liquid plant wastes are briefly discussed. Experiments that were conducted to achieve ultimate disposal of these concentrated waste materials are also discussed. An installation which currently disposes of an oily waste is described.

07804

Incinerator Inst. of America, New York, N. Y.

I. I. A. INCINERATOR STANDARDS. 32p., May 1966.

A guide for satisfactory incinerator operation, mixtures of waste waste most commonly encountered have been classified into types of waste, together with the B.T.U. values and moisture contents of the mixtures. A concentration of one specific waste in the mixture may change the B.T.U. value and/or the moisture content of the mixture. A concentration of more than 10% by weight of catalogues, magazines, or packaged paper will change the density of the mixture and affect burning rates. Similarly, incinerators have been classified, by their capacities and by the type of wastes they are capable of incinerating. The Standard includes design and construction requirements and lists the procedure used for capacity, smoke density and fly-ash emission tests.

07963

Rohrman, F. A., B. J. Steigerwald, and J. H. Ludwig

**POWER PLANT AND OTHER SULFUR DIOXIDE EMISSIONS; 1940-2000.** Preprint, Public Health Service, Cincinnati, Ohio, Division of Air Pollution, ((13))p., ((1965)). 21 refs.

Major sources, potential sources, estimated annual emissions and the effects of probable control efforts of Sulfur Dioxide to the year 2000 are discussed. The major sources include power

plant operation (coal and oil); other combustion of coal; combustion of petroleum products (excluding power plant oil; smelting of ores; petroleum refinery operation; coke processing; sulfuric acid plants; coal refuse banks; and refuse incineration). Annual emission of Sulfur Dioxide is 76.0 million tons. To indicate a range of estimated future sulfur dioxide emissions, two control schedules were selected for application to the major sources of SO<sub>2</sub> from the current year to the year 2000. Maximum SO<sub>2</sub> emissions will probably occur between 1975 and 1985 for the range of control schemes postulated.

08090

Peskin, L. C.

**THE DEVELOPMENT OF OPEN PIT INCINERATORS FOR SOLID WASTE DISPOSAL.** Preprint, Thermal Research and Engineering Corp., Conshohocken, Pa., ((9))p., 1966. (Presented at the Air Pollution Control Association, San Francisco, Calif., June 20-24, 1966.)

A discussion is presented of a newly developed incinerator for the disposal of solid wastes. It is distinguished from conventional types by its open top, and features a system of closely spaced nozzles admitting a screen of high velocity air over the burning zone. Results, with a variety of solid industrial wastes, show high burning rates, leading to complete combustion and high flame temperature. (Author's abstract)

08373

Baum, Fritz and Wolfgang Steinbach

**WASTE INCINERATION IN SMALL UNITS.** Staub (English translation), 27(7):23-25, July 1967. 10 refs. CFSTI: TT 67-51408/7

The incinerator investigated has a triple jacket combustion chamber, and is heated up and charged with dry paper waste. The CO and CO<sub>2</sub> concentration was recorded by infrared gas analyzers. During charging, CO concentration rose rapidly to 0.4-0.6 vol.% then dropped gradually. CO<sub>2</sub> concentration rose rapidly to 1.0-1.5 vol. percent, then dropped slowly. The CO and CO<sub>2</sub> concentrations were as a rule much lower than with medium units. Measurements to determine the emission of solids were performed with a Strohlein instrument at the chimney end. The results yielded a solid concentration between 300 and 425 mg/cu m. Large quantities of hydrocarbons were deposited on the measuring filters apart from solids, which gave an impression of a deceptively high dust emission. The strong hydrocarbon development was confirmed by observations and measurements. For a long time white-gray clouds were emitted from the chimney, causing noxious odors in the vicinity.

08577

Setti, Bruno and Giuseppe Andreoni

**REFUSE INCINERATORS OF MILAN AND THE AVAILABILITY OF THEIR HEAT FOR HEATING URBAN QUARTERS.** ((L'impiego di incenerimento dei rifiuti di Milano e la loro disponibilit  di calore per riscaldamento di urbani.)) Text in Italian. Fumi Polveri (Milan), 7(6-7):135-147, June-July 1967. 2 refs.

The refuse incinerator plants of the city of Milan could be adapted for use as a source of energy for heating. The economic potential is using heat from refuse incineration is discussed. A table shows the various components of refuse (first by size, then listing paper, vegetables, organic matter, etc.) with their percentages of the total, their percent water and ash content, and the potential calories they would produce. It is estimated that the 4 incinerators described burn

2 million kg/day of rubbish and produce 2,000 megacalories which could be converted into 280 million kw hrs, sufficient for many public services (trains, illumination, water), or for heating 35,000 buildings. Air pollution would be lessened by the better utilization of energy.

08583

Schiemann, G.

**RESULTS OF EMISSION MEASUREMENTS FROM COMMUNITY INCINERATORS.** ((Ergebnisse von Emissionsmessungen an Verbrennungsanlagen fuer Siedlungsabfaelle.)) Text in German. Brennstoff-Waerme- Kraft (Berlin) 19(9):440-443, Sept. 1968. 3 refs.

The dust and gas emissions of one large and 47 small and medium incinerator plants in Duesseldorf and Cologne were measured and compared. In 75% of the small and medium plants which employed various control methods the smoke plume was under the limiting value, while the dust discharge exceeded the standard. These results showed that poor dust control rather than the incineration itself was at fault. After various alterations, the small and medium plants were able to meet the dust emission standards. Dust emission in the smaller and medium plants before alterations was 4 kg./hr. for 2.5 t./hr. of refuse, while a large incinerator plant equipped with a roller grate and oil furnace, and electrostatic precipitators, showed only 3.2 kg./hr. dust emission for 20 t./hr. of refuse. The highest SO<sub>2</sub> emission was 1.5 g./cu m, only traces of SO<sub>3</sub> were found, and the hydrochloric acid content of the stack gas was 0.1-1.1 g./cu m. It was concluded that whenever possible, the more economical and safer large incinerator plants should be constructed.

08816

Rose, Gerhard

**WILL TRASH REMOVAL BE A MARKETING FACTOR FOR THE GLASS CONTAINER INDUSTRY AND PRODUCERS OF OTHER PACKAGING MATERIAL?** ((Wird die Abfallbeseitigung zu einem Marktfaktor fuer die Verpackungsglasindustrie und die Hersteller anderer Verpackungsmittel?)) Text in German. Glastech. Ber., 40(11):438-438, Nov. 1967.

While the removal of discarded glass containers presents a problem, it is not insurmountable, particularly if refuse crushing plants and techniques are developed which will refuse the silicon from waste glass. The substitution of plastic packaging materials for glass has the disadvantage that during incineration of poly vinyl-chloride-containing material, corrosive gases are evolved, which cause severe damage to the boiler units of the incinerator plant. Furthermore, the emission of hydrochloric and hydrofluoric acids from these plastics causes dangerous air pollution to such an extent, that in the United States the incineration of plastic waste is forbidden in the vicinity of large cities.

08850

Stephenson, John W.

**DISPOSAL OF COMMUNITY WASTES.** Public Health Inspector, 76(2):98-110, 113-114, 132, Nov. 1967.

Community waste disposal is a problem of increasing complexity. It is a challenge to local authorities which must be met by adequately financed research, ingenuity, and determination to devise and use techniques appropriate to the problem. Some of the approaches to disposal of solid wastes are controlled tipping, incineration, pulverization, and composting. The disposal of liquid wastes is dependent on treatment processes for sewage such as sedimentation, biological filters, humus

tanks, and activated sludge. The disposal of trade wastes can have a profound effect on the efficiency of sewage disposal works. Some causes of trouble have been listed together with the problems created.

09026

Burckle, J. O., J. A. Dorsey, and B. T. Riley

**THE EFFECTS OF THE OPERATING VARIABLES AND REFUSE TYPES ON THE EMISSIONS FROM A PILOT SCALE TRENCH INCINERATOR.** Preprint, Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, ((28))p., 1968. 19 refs. (Presented at the National Incinerator Conference, New York, N. Y., May 5-8, 1968.)

This work defines the air pollutant emissions from a Trench Incinerator burning three types of refuse material: low ash, moderately high heat content materials characterized by cord wood; high ash, high heat content material characterized by rubber tires; high ash, low heat content material characterized by municipal refuse. Use of a trench incinerator for the disposal of the high ash content materials studied generated particulate emissions which, in all cases, exceeded 1 grain per standard cubic foot at 12 per cent carbon dioxide and is therefore not recommended. For disposal of low ash, high heat content materials, the data indicate that, except for nitrogen oxides, emission levels from the trench incinerator may be acceptable if rigid operating controls are predetermined for the specific refuse material. (Author's abstract)

09158

Deming, LeRoy R. and John M. Connell

**THE STEAM GENERATING INCINERATOR PLANT.** In: Proc. Power Conference 28th Ann. Meeting, Chicago, Ill., April 26-28, 1966, Volume 28, p. 652-660. 3 refs.

A concept of plant arrangement to serve two 180-ton per day water-cooled furnace steam generators, requiring a minimum investment in plant and structures, is shown. A continuous availability of steam for export is essential. This dictates the requirement for an alternate or supplementary fuel. Economical evaluation will determine whether coal or oil should be used. The refuse storage facility design should contemplate the stacking of the refuse during the interval when the crane is not charging the chute to the furnace. Provision should be made for access to the storage pit by a front end loader to facilitate cleanup of the pit as the refuse is exhausted. Extreme care should be exercised to insure rat proofing of all drainage and other openings. A scale should be provided for weighing the refuse. An intercommunication system, connecting the crane operator to the truck dumping area, will permit remote supervision when the rate of deliveries is inadequate to require the presence of a full-time man at the truck dumping area. The water-walled steam generating incinerator at the United States Naval Operating Base at Norfolk, Virginia, is described in detail. Total refuse production in the United States in 1965 and projections to 1980 are given. The energy available in refuse and its coal equivalent is given.

09663

Cohan, L. J., and J. H. Fernandes

**POTENTIAL ENERGY-CONVERSION ASPECTS OF REFUSE.** American Society of Mechanical Engineers, New York, Paper 67-WA/PID-6, 8p., 1968. (Presented at the Winter Annual Meeting and Energy Systems Exposition, Pittsburgh, Pa., Nov. 12-17, 1967.)

The rate at which waste is being generated in alarming—the figures for the future are staggering. Volume reduction is a



## A. EMISSION SOURCES

9

must. Incineration of refuse offers an excellent solution since this method produces energy in a form which can be readily harnessed and utilized to offset the cost. The control of off-gases and waste water and the removal of their contaminants can be accomplished and managed through process engineering applications. Some of the prospects are: (1) regenerative feed-water heating, (2) district heating, (3) district air conditioning, (4) refrigeration, (5) desalination, (6) separately fired superheaters, and (7) incinerator gas turbine. But there are many problems and the solutions are complex. Society has the right to look to the engineering community for such solutions.

09671

Elmer R. Kaiser

**THE NEED FOR A TEST CODE FOR LARGE INCINERATORS.** American Society Mechanical Engineers, Paper 67-WA/PTC-4, 4p., 1967. (Presented at the Winter Annual Meeting and Energy Systems Exposition, Pittsburgh, Pa., Nov. 12-17, 1967.)

A 16-man committee has been named by the American Society of Mechanical Engineers to draft a performance test code for incinerators that burn more than 2000 lb. of refuse per hour. The paper presents the considerations which led this action, and outlines the scope, and the technical features that will engage the new committee's attention. (Author's abstract)

09676

A. Porteous

**TOWARDS A PROFITABLE MEANS OF MUNICIPAL REFUSE DISPOSAL.** American Society Mechanical Engineers, Paper 67-WA/PID-2, 17p., 1967. 26 refs. (Presented at the Winter Annual Meeting and Energy Systems Exposition, Pittsburgh, Pa., Nov. 12-17, 1967.)

Refuse disposal processes which can generate revenue from the sale of by-products are studied. Economic evaluation of several alternatives reveals ethanol production from the wastepaper content of the refuse to have strong profit potential. This is studied in depth and a design proposed with sufficient flexibility to enable the process to function profitably despite chemical kinetic uncertainties. Further work is recommended to take ethanol production from refuse to the pilot-plant stage with the ultimate objective of full-scale municipal installation for refuse processing. (Author's abstract)

09686

R. L. Duprey

**COMPILATION OF AIR POLLUTANT EMISSION FACTORS.** Public Health Service, Durham, N. C., National Center for Air Pollution Control, Publication No. 999-AP-42, 67p., 1968. 126 refs.

Detailed emission factors are given for the following processes and industries: fuel combustion, refuse incineration, chemicals, food and agriculture, metallurgical refining, minerals, petroleum, pulp and paper solvent evaporation and gasoline marketing, and transportation (vehicle emissions).

09785

Dickinson, Janet, Robert L. Chass, and W. J. Hamming

**AIR CONTAMINANTS.** In: Air Pollution Engineering Manual. (Air Pollution Control District, County of Los Angeles.) John A. Danielson (comp. and ed.), Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, PHS-Pub-999-AP-40, p. 11-21, 1967. GPO: 806-614-30

The parameters of an air pollution problem, particularly the problem in Los Angeles County; the measures taken to eliminate the problem; and control measures still needed are described. The air contaminants include: organic gases (hydrocarbons, hydrocarbon derivatives); inorganic gases (NO<sub>x</sub>, SO<sub>x</sub>, CO); miscellaneous inorganic gases (NH<sub>3</sub>, H<sub>2</sub>S, Cl<sub>2</sub>, F<sub>2</sub>); particulates (carbon or soot particles, metallic oxides and salts, oily or tarry droplets, acid droplets, metallic fumes). Each is discussed indicating the sources and significance in the air pollution problem.

10038

Dvirka, Miro and A. B. Zanft

**ANOTHER LOOK AT EUROPEAN INCINERATION PRACTICES.** Public works, 98(7):99-100, July 1967.

Solid waste incinerators in Dusseldorf, Rotterdam, Paris and Vienna are briefly described. The installations generally have furnaces which are adapted for steam generation in addition to waste burning. Incinerator operation and refuse quality are discussed. The percentage of combustibles, non-combustibles, and water content as well as the heating value of the refuse for each city is presented.

10418

K. S. Basden

**INCINERATOR INSTRUMENTATION SYSTEMS.** Clean Air (J. Clean Air Soc. Australia, New Zealand) 2(1):18-22, March 1968. 10 refs.

The purposes of instrumentation of a modern high temperature municipal incinerator are discussed, together with a brief description of some categories of instruments with which such a plant would be equipped. The subject of automatic control of incinerator plants is introduced and particular applications which would be economically feasible on a modern incinerator installation are mentioned. (Author's abstract modified)

10424

Graham J. Cleary

**THE CONTRIBUTION OF DIFFERENT SOURCES TO POLLUTION BY POLYCYCLIC AROMATIC HYDROCARBONS.** Clean Air (J. Clean Air Soc. Australia New Zealand) 2(1):13-17, March 1968. 40 refs.

The contribution from automobile exhausts, coal combustion sources, products from the combustion of gaseous and liquid fuels, tire rubber, and incinerator effluents to atmospheric pollution by polycyclic hydrocarbons is examined briefly. Concentration ratios for the compounds 3,4 benzopyrene/1,2 benzoperylene and for 3,4 benzopyrene/coronene are used to examine the mode of pollution in Sydney and to compare this pattern with other cities in Great Britain and the United States of America. (Author's abstract)

10433

Kirov, N. Y.

**DISPOSAL OF MUNICIPAL REFUSE BY INCINERATION.** Clean Air (J. Clean Air Soc. Australia New Zealand), 2(1):5-118 Mar. 1968.

The problem of hygienic refuse disposal, which is of major and growing concern to Municipal authorities, is a direct consequence of population growth and technical advances characterizing our present day industrialized civilization. For reasons given in the paper, incineration of municipal refuse by modern high temperature techniques has become during the past fifteen years the preferred method of refuse disposal in most of

## MUNICIPAL INCINERATORS

the large cities of the world. An outline of the objectives of high temperature incineration is followed by considerations of refuse as a fuel and of the basic requirements for its efficient combustion. The main part of the paper, however, is concerned with the advances and principal design features of modern incinerator plant and of the various firing systems which have led to the successful developments in municipal refuse incineration practice throughout the world. (Author's abstract)

10675

Feuss, James V. and Fradklid B. Flower

**THE DESIGN OF APARTMENT HOUSE INCINERATORS - THE STATE OF THE ART.** Preprint, 36p., 1968. 14 refs. (Presented at the 61st Annual Meeting of the Air Pollution Control Association, St. Paul, Minn., June 1968, Paper 68-186.)

Information concerning the design of apartment house incinerators and their emission standards was organized for the training of and use by local officials concerned with air pollution control. The differences and similarities among many state and local air pollution ordinances concerning apartment house incinerators are graphically illustrated. Incinerator emission standards are reduced to a common base and charted against incinerator capacities. Grate loadings, arch heights, retention times in primary and secondary chambers, and heat releases of the various designs are compared graphically over a range of burning rates. After reviewing the several graphs it becomes obvious that there are striking inconsistencies among the codes. At a burning rate of one million Btu (British thermal units) per hour, the primary combustion chamber heat release rates range from 10 to 70 thousand Btu/cu. ft./hr. At burning rates of one million Btu./hr., the theoretical retention times in the primary combustion chambers range from about 1/2 to 4 seconds. The recommended maximum grate and hearth loadings for incinerators with burning capacities of 200 per hour range from 8 to 30 pounds per square foot. At a burning rate of 30 lbs./hr., the emission standards range from 0.11 to almost 1.1 grains/standard cu. ft. corrected to 12% carbon dioxide. Design formulas and criteria are evaluated and recommendations for evaluating incinerator design and operation are given.

10678

Bachl, Herbert

**DISTRICT HEATING, WASTE INCINERATION AND ELECTRIC NIGHT-TARIFF HEATING, AND AIR POLLUTION CONTROL IN MUNICH.** Staub (English translation), 28(2):17-31, Feb. 1968. CFSTI: TT 68-50448/2

As a result of special meteorological conditions, inversions frequently occur in Munich. First, the results of immission measurements are reported, which were carried out in different town regions, and then the preventive measures introduced are explained. The influence of different types of fuel and of various heights of chimneys on SO<sub>2</sub> emissions is discussed. The development of long distance heat supply and of electric heating is combined with direct burning of natural gas. The power plant which is situated in the town and comprises installations for long distance heat supply and for refuse incineration has proved to be highly expedient. Coal is preferably used as the additional fuel in the power plants situated at town outskirts, whilst natural gas is used in the power plants situated in the town centre. 10688 Bachl, Herbert

**DISTRICT HEATING, WASTE INCINERATION AND ELECTRIC NIGHT-TARIFF HEATING, AND AIR POLLUTION CONTROL IN MUNICH.** Staub (English translation), 28(2):18-31, Feb. 1968. CFSTI: TT 68-50448/2 EMISSION

**SOURCES:** Domestic heating, Power production, Incinerators As a result of special meteorological conditions, inversions frequently occur in Munich. First, the results of immission measurements are reported, which were carried out in different town regions, and then the preventive measures introduced are explained. The influence of different types of fuel and of various heights of chimneys on SO<sub>2</sub> emissions is discussed. The development of long distance heat supply and of electric heating is combined with direct burning of natural gas. The power plant which is situated in the town and comprises installations for long distance heat supply and for refuse incineration has proved to be highly expedient. Coal is preferably used as the additional fuel in the power plants situated at town outskirts, whilst natural gas is used in the power plants situated in the town centre.

11411T

M. Andritzky

**GARBAGE POWER PLANT MUNICH.** (Müllkraftwerk München.) Translated from German. Brennstoff-Waerme-Kraft (Duesseldorf) 14(5):232-233, 1962.

The refuse power plant in Munich is described and the seasonal changes of the garbage collected (composition and heating value shown in graphs) are described in comparison to those in Antwerp, Rotterdam and Vienna. The power plant burns approximately 60% coal dust and 40% garbage in separate combustion rooms of a common high-pressure steam generator. The first version of the plant has a capacity of 68 million watts and supplies steam for a long-distance heating system. After the second construction phase and a capacity of 100 million watts, all garbage collected in the city of Munich can be burned in this plant. The installation is shown in a diagram. Purification of the flue gas is emphasized. An electro filter providing 99.75% dust removal is mentioned, and the pneumatic transport of flue ash from the boiler to a collecting bunker is described. The proximity of an airport limited the height of the smokestack to 80 meters.

11412T

W. Engel, A. von Weihe

**EXPERIMENTAL REFUSE INCINERATION PLANT OF THE DUESSELDORF MUNICIPAL WORKS, FLINGERN POWER PLANT.** (Müllverbrennungs- Versuchsanlage der Stadtwerke Duesseldorf, Kraftwerk Flingern.) Translated from German. Brennstoff-Waerme-Kraft (Duesseldorf) 14(5):234-236, 1962.

The experimental refuse incineration plant in Duesseldorf consists of a charging facility, several consecutive roller grates and a traveling grate. These units are coupled and electrically regulated. The experimental plant was put into operation on 21 March 1961 and by the beginning of February, 1962 had processed 140,000 cu m of refuse in approximately 3500 operating hours. The comparison of the official measurements for the incineration of Duesseldorf refuse on forced-feed and travel grates with measurements in the experimental plant show the following advantages for the experimental plant: Its firing efficiency is 83%, approximately 30 percent higher than the tests on forced feed grates. Since the firebox temperature is correspondingly higher, it fulfills all hygienic requirements which can be made of a refuse incineration plant. The accumulation of fly dust in the raw gas is considerably below the values driven in comparable tests with force-feed grate. In the summer months it is 1 g per cu m, in the winter months it is 2 to 2.5 g per cu m. No noxious components were detected in the flue gases. The operational results have confirmed that the roller grate is the suitable equipment for a refuse incineration plant.



## A. EMISSION SOURCES

11413T

H.F. Kammerer

**WASTE INCINERATION PLANT WITH HEAT UTILIZATION IN STUTTGART.** (Müllverbrennungsanlage mit Heizwaermeverwertung in Stuttgart.) Translated from German. Brennstoff-Waerme-Kraft, 14(10):476-478, 1967. 2 refs.

The development of the waste incineration plant with heat utilization in Stuttgart Germany, is discussed briefly and the essential elements of the plant are described. It incorporates the knowledge gained from existing refuse power plants and experimental plants adapted to local conditions. The power plant burns heavy fuel oil and refuse in separate combustion chambers of a common steam generator. Electrofilters with a 98 percent degree of separation are planned for removal of dust. The heat produced is fed into the city heat supply via the steam collecting lines of the power plant. The heat utilization system is illustrated and discussed. A steam generation of approximately 30 tons/hr per refuse furnace is expected. Economic aspects, including capital cost, are briefly mentioned.

11427T

Albinus, G.

**INCINERATION OF REFUSE: FUNDAMENTAL CONSIDERATIONS ON THE PROBLEM OF TRASH DISPOSAL BY INCINERATION.** (Muellverbrennung: Grundsatzliche Ueberlegungen zu Fragen der Muellbeseitigung durch Verbrennen.) Translated from German Brennstoff-Waerme-Kraft, 14(5):215-217, May 15, 1962.

The difficulties encountered in the disposal of refuse by incineration are discussed. The properties of refuse, the possibilities of influencing the heating value, and the technological processes of household waste incineration are discussed, and the requirements for the construction of the firebox are deduced from them. The incineration process can only proceed satisfactorily if the following basic conditions are fulfilled: The trash must have a satisfactory supply of oxygen; the trash and the oxygen in the air must have as close a contact as possible, for example by loosening the fuel bed; and a complete combination of the oxygen with the trash requires sufficiently high ignition and combustion temperatures. The types of trash incineration, the dust problem, and heat utilization are also discussed.

11428T

Mueller, H. J.

**TRASH INCINERATION ACCORDING TO THE VOLUND SYSTEM.** ((Die Muellverbrennung nach dem System Volund.)) Translated from German. Brennstoff-Waerme-Kraft, 14(5):219-223, 1962. 13 refs.

The installation of St. Ouen (Paris) and its operational results are presented as examples of the Volund trash incineration system. The trash is piled as high as 30 meters and fed into the filling funnel, which unilaterally tapers downward, by two orange peel buckets (one in reserve) each with 3 cu m volume capacity and a load capacity of 6 tons. The trash moves through a shaft to the drying grate where it is dried by the radiation from the drying chamber and the convection of the flue gases rising out of the incineration chamber. The flue gases with a high steam content which are produced during the drying process are passed through a 13.5 m long vapor channel into the mixing and after-burning chamber. On a second grate, the incineration grate, the trash is finally ignited and burned. From the experience of this installation which has a throughput of 323,000 tons per year of trash, the largest of its kind in Europe, a combination of the rotary-drum furnace with

a waste heat boiler was developed which has favorable space utilization through combining the drying, incinerating, and heat transfer components into a single unit.

11429T

Zankl, W.

**THE CELL GRATE TRASH DISPOSAL INSTALLATION.** ((Die Zellenrost-Muellvernichtungsanlage.)) Translated from German. Brennstoff-Waerme-Kraft 14(5):224-225, 1962.

The basic construction principles of a cell grate incinerator trash disposal installation system are described. Such installations (of which some 274 have been built since 1901) are suited for a capacity of roughly 1.5 tons per 24 hours. Utilization of the heat produced generally can be considered only in terms of steam or hot water production, primarily for supplementing an already established heating network. Linkage with an electrical current generation system is scarcely economical in this size range. The installation is illustrated by a diagram and photographs. No reference to air pollution is made.

11430T

Kern, A.

**VIEWS ON THE DESIGN OF MODERN INCINERATION INSTALLATIONS FOR URBAN TRASH.** ((Gesichtspunkte fuer die Auslegung neuzeitlicher Verbrennungsanlagen fuer Stadtmuell.)) Translated from German. Brennstoff-Waerme-Kraft, 14(5):225-227, 1962.

Some economic considerations on refuse incineration, particularly on the problem of conditions suitable to the utilization of heat produced, are given. The guarantees and construction conditions which must be considered in the evaluation of a trash incineration installation are discussed. Low flue gas velocities must be chosen and opportunities for the removal of flue ashes inside the boiler must be created, in order to keep the abrasive effect of high sand content in the trash on the boiler tubes low. Flue gases from trash incineration must be cooled before entering the boiler to a point below the softening temperature of the trash ashes. Clogged tube arrangements are above all to be avoided in the connected heating surfaces, since deposits which cannot be removed by the ordinary cleansing apparatus, such as ball-moving and soot blowers, will of necessity have to be removed by hand. Slag must be discharged without raising dust and must be tightly air-sealed against the firebox. A high quality dust-removal device must be present. The Martin system, the Sao Paulo incineration installation, and the trash power plants now under construction in Rotterdam and Munich are characterized.

11431T

Kampschulte, J.

**GARBAGE INCINERATORS IN HAMBURG AND THEIR EXTENSION THROUGH THE ADDITION OF VON-ROLL-INCINERATORS.** ((Die Muellverbrennung in Hamburg und ihre Erweiterung durch von-Roll-Oefen.)) Translated from German. Brennstoff-Waerme-Kraft 14(5):228-231, 1962. 10 refs.

The extension and modernization of the refuse furnace plant located in Hamburg, Germany by the addition of two von-roll refuse incinerators with a capacity of burning a charge of 200 tons per 24 hours, each with one auxiliary waste-heat boiler (with a boiler power of 15.5 tons per hour) is described and illustrated. The experiences gained in the operation of these furnaces are reported. When three more of these furnaces will be operational, it will be possible to burn more than one million cu m of garbage annually and to produce 60 to 80 GWH. Further development of the system will lead from an incinera-



tor with a waste-heat boiler to a uniformly structured garbage incinerator with an initial charge of 200 tons per 24 hours, which will require considerably less space.

11432T

**GARBAGE INCINERATION PLANT COMBINED WITH THE DRYING AND BURNING OF SEWAGE SLUDGE.** ((Mullverbrennungsanlage kombiniert mit Trocknung und Verbrennung von Klarschlamm.)) Translated from German. Brennstoff-Waerme-Kraft, 14(5):231, 1962.

A refuse incineration plant combined with the drying and burning of sewage sludge for a town of approximately 14,000 inhabitants is described. Simultaneously with the burning of garbage, a drier for the sewage sludge is combined with the garbage combustion, with the latter furnishing the heat necessary to dry the former. This permits the efficient utilization of the heat produced by combustion. After drying, the sewage sludge is burned along with the garbage in the incinerator. The plant is calculated for a normal output of 3 tons per hour. A diagram of the process is shown.

11438T

Moegling, E.

**PRACTICAL ASPECTS OF REFUSE INCINERATION ON THE EXAMPLE OF ESSENKARNAP.** ((Praxis der zentralen Mullverbrennung am Beispiel Essen-Karnap.)) Translated from German. Brennstoff-Waerme-Kraft, 17(8):383-391, Aug. 1965. 2 refs.

Various aspects involved in the planning of refuse incineration plants are discussed. Detailed data of the Essen-Karnap power plant which serves a very wide area of refuse collection, are given. This plant is the largest refuse incineration plant existing at present. It has a capacity of 2000 tons of domestic and industrial refuse and 2000 tons of sludge per day. Performance data, components of the refuse power plant, supply and storage facilities for household refuse, discharging of refuse, refuse transportation and loading, incineration of used oils, slag transportation and treatment, and furnace operation are described. Simultaneous co-incineration of high-calorific value industrial refuse is being attempted experimentally. A large portion of the acid-forming ingredients undergoes chemical reaction with the refuse slag and fly ash originating from powdered coal firing, thereby reducing the emission of SO<sub>2</sub>, SO<sub>3</sub>, HCl, etc. into the flue gas. The aim is to establish a ratio of industrial wastes to domestic refuse which will provide the desired flue gas composition. At present refuse to be incinerated must contain less than 1% sulfur.

11439T

**ON THE STATE OF REFUSE INCINERATION IN GERMANY.** ((Zum Stand der Mullverbrennung in Deutschland.)) Translated from German. Brennstoff-Waerme-Kraft, 17(12):594-595, Dec. 1965.

Refuse incineration plants operating in 17 different German cities are listed, together with their capacities and methods of incineration, steam output, main fuel used, and furnace design. The ranges of refuse calorific value (kcal/kg) and the method of flue gas cooling (chiefly by steam generation, in one case air, one water, one clarifier sludge drying) are tabulated. The following grate systems are used in the individual plants: moving grate, advancing and retracting grate, rotating and tipping grate and Volund rotating furnace. By 1970 there will be an installed capacity of 3 million tons per year in West Germany. This assumes planned and ongoing new construction in Berlin, Frankfurt and Munich, as well as in eight other cities. No air pollution aspects are specifically discussed.

11440T

Knoll, H.

**REFUSE INCINERATING PLANT OF THE CITY OF NUERNBERG.** ((Mullverbrennungsanlage der Stadt Nurnberg.)) Translated from German. Brennstoff-Waerme-Kraft, 17(12):595, b8dec. 1965.

The refuse incineration plant in Nurnberg (Germany), scheduled for operation in fall of 1968, is described. It has a daily capacity of 300-360 tons of refuse. New types of oil fired furnace chambers are used: the temperature of the combustion gases is kept low by the admixture of secondary air, preventing the slag from baking together. The steam boilers generate steam of 84 atm and 450 deg. C and have a capacity of 27-34 tons/gr each. A new autoclave process for sludge clearing is also being designed. The sludge is sterilized by heating to 200 deg C, the colloids are broken, the sludge is filtered and the dry sludge is ground and used as fertilizer. 200 tons of dried sludge (40% water content) will be produced per week. Eventually the plant may be enlarged to supply some 450 tons of dried sludge per week. It is estimated that 50% of the sludge will be used in agriculture and the remainder—representing about 10% of the entire amount of refuse—will be incinerated. Air pollution aspects are not discussed.

11447T

Palm, R.

**COMPOSITION OF REFUSE AND REFUSE INCINERATION.** ((Mullzusammensetzung und Mullverbrennung.)) Translated from German. Aufbereitungs-Technik, 4(12):561-565, Dec. 1963. 8 refs.

An attempt is made to characterize refuse by its constituents. The refuse is differentiated according to various mixing proportions of the lignitic constituent and the coal component. The kinds of mixtures within each component have been classified in accordance with their percentage of really combustible materials and the content of real slag. The burning conditions in these groups, i.e. the quantities of smoke gas produced and the burning temperature as a function of the useful heating power, can be determined provided the estimated melting point of the slag is taken into account. It is advisable to judge the burning conditions on the basis of the types of refuse, according to the region, the customs and working conditions of the population and the supply of fuel and the heating methods practiced in the region. The composition of refuse from some European and American cities, and its effect on combustion is discussed. Analyses of the slag from refuse are important. The properties of the slag influence not only the temperature and the combustion conditions in the different layers of the combustible, but will determine whether the flue gases are suitable or not for the production of energy. It is especially important to know the temperatures that can be obtained in the combustion chamber, with the different types of refuse. The admissible temperature of the fire-bed is determined by the supposed melting temperature of the slag. The air excess will be determined correspondingly. The melting point of the refuse slag which may not be exceeded lies between 1000 and 1440 deg. C.

11448T

Peters, Wulf

**METHODS OF REFUSE INCINERATION WITH PARTICULAR CONSIDERATION OF THE CONDITIONS IN GERMANY.** ((Die Verfahren der Mullverbrennung unter besonderer Berucksichtigung der deutschen Verhaltnisse.)) Translated from German. Aufbereitungs-Technik, 1(8):329-339, Aug. 1960. 19 refs.

A short historical review covering the 65 years of refuse burning in Germany is followed by a description of the plants at Hamburg that are still in action and of the reconstruction and enlargement they are currently undergoing. The preliminary investigations that preceded the designing of an incineration plant for industrial waste are described. A project that will be constructed in an industrial area is listed as an example of the plans under consideration in numerous German cities. This project provides for a large burning plant in an existing power station. Some of the systems of refuse burning offered by German firms are described.

11449T

Kallenbach, K.

**TRASH INCINERATION PLANT WITH ROLLER GRATE FIRING FOR THE CITY OF HAGEN.** ((Müllverbrennungsanlage mit Walzenrostfeuerung für die Stadt Hagen.)) Translated from German. Brennstoff-Wärme-Kraft, 16(8):406-407, Aug. 1964.

A trash incineration plant with roller grates to be constructed in Hagen, Germany is briefly described. The installation includes 3 firing units with a maximum trash throughput capacity of 6 tons per hour, each corresponding to a total trash throughput of more than 400 tons per day. The recovery of heat or the sale of the steam or hot water should be possible at any time and on such a scale that delivery contracts could be concluded.

11450T

**TRASH PREPARATION WITH THE GORATOR.** ((Müllaufbereitung mit dem Gorator.)) Translated from German. Brennstoff-Wärme-Kraft, 16(8):404-405, Aug. 1964.

The slanted runner machine ((Gorator)) is suited for the moving, pulverization, mastication, and mixing of nonhomogeneous materials of the most varied types including, fibrous, doughy, and highly viscous materials, muds, and solid fuels. It has been proposed that it also be used for the homogenization of refuse if necessary with the admixture of combustibles in order to allow the transportation of a more uniform material with a finer structure to the refuse incineration installation. For this purpose, the Loading-Screw Gorator is especially well suited. The operation of the Gorator is described and illustrated.

11461T

Tanner, R.

**THE DEVELOPMENT OF THE VON ROLL-INCINERATION PLANTS.** ((Die Entwicklung der Von Roll-Müllverbrennungsanlagen.)) Translated from German. Schweiz. Bauztg., Vol. 83, p. 251-260, April 22, 1965. 11 refs.

The engineering history during the 20 year development of the Von Roll refuse incineration system is described and the results evaluated. The experiences and observation of the rotary drum furnace in Basel led to the replacement of the drum by a perpendicular shaft (slag generator) as a burn-out element, a development which substantially reduced the dimensions of the furnace. In another plant in Hamburg, the arrangement of the predrying and main grates was changed so that they were one behind the other, moving in the same direction. As a result, the delicate false floor of the Bern type was discarded. The application of down-draft preheating and flue gas recycling in another plant in Hamburg, allowed a substantial increase in capacity. Future developments and the technical possibilities of refuse incineration today are discussed. Few references to air pollution are made, except

for incidental mention of such points as 'smoke limit-about 750 deg C', boiler cleansing, and used oil incineration. A brief concluding paragraph discusses the German norm of 150 mg/Nm<sup>3</sup> as the maximum allowable concentration of dust emitted from smoke stacks, and mentions 80 to 120 meters as effective stack heights. Harmful gases are mentioned but no discussed.

11475

Kuwata, M. and R. H. Essenhigh

**COMBUSTION BEHAVIOR OF SUSPENDED PAPER SPHERES.** (TECHNICAL REPORT.) Pennsylvania State Univ., University Park, Dept. of Fuel Science, TR-FS/PHS-68-1, 173P., 1968. 21 refs.

Paper sphere combustion was studied as a part of a program on abatement of smoke and grit emission from incinerators. Its 33(4-6):13-17, April-June 1968. ((10)) refs. Paper was chosen as a representative material of incinerators, and the shape of the sample, a sphere, was selected because of its well defined symmetry. The experimental system used was that of a single paper sphere suspended, in a 3 in dia horizontal combustion tube, from a recording analytical balance. Simultaneous measurements of weight and diameter were made on the sphere during burn-off by the balance and using a specially designed camera. Radial temperatures history of samples were also measured during reaction by Pt-Pt/10% Rh thermocouples implanted in the spheres, although these were made as additional support experiments. The paper spheres ranged from 0.8 to 4.5 cm in their initial diameters. The running condition used ranged from zero to 160 cm/sec in gas speeds, and from 15% to 70% in oxygen concentration. The results of this investigation have led to the following conclusions. (1) The reaction of the paper spheres was governed by oxygen diffusion through the boundary layer to the surface of the sphere, except in the case of air velocities more than 120 cm/sec and the initial diameters of the spheres more than 2 cm. (2) In the special case mentioned above the reaction of the paper spheres was governed by the chemical kinetics of the reaction, although its details were not studied here. (3) The pyrolysis and the char combustion were substantially independent, though both were proceeding simultaneously for 80 or 90% total weight loss.

11636T

Wotschke, J.

**UNIVERSAL WASTE REMOVAL AND ITS REALIZATION WITH THE FLAME CHAMBER MELTING PROCESS.** ((Universale Abfallbeseitigung und ihre Verwirklichung durch das Flammkammer-Elaschmelzverfahren.)) Translated from German. Brennstoff-Wärme-Kraft, 16(8):383-391, Aug. 1964. 23 refs.

The flame chamber melting process meets the requirements for a truly universal process for refuse disposal. It is able to accept and process all waste whether it is in solid, liquid, or gaseous form without shying away from calorific values which are too high or too low, or from difficult combustion or slag behavior. The process is described and illustrated. The melting process eliminates the difficulties of refuse incineration by considerably increasing the incineration temperature. The refuse lining the flame chamber is completely dissolved into dust-free, hot flue gas generated by combustible matter and into melted matter from incombustible objects. It allows for a considerable reduction of the volume of slag and better properties of this slag for storing and use. Theoretical aspects of the process are considered in detail. The technical solution for using the flame chamber process is illustrated for two cases, one for 5,000 kg per hr refuse throughput corresponding to about 100,000 inhabitants and one for 500 kg per hr cor-



## MUNICIPAL INCINERATORS

responding to about 10,000 inhabitants. In both cases the same processing characteristics are present.

11637T

Andritzky, M.

**SECOND EXTENSION OF THE REFUSE POWER PLANT IN MUNICH.** ((Zweiter Ausbau des Mullkraftwerks Munchen.)) Translated from German. Brennstoff-Waerme-Kraft, 16(8):403, Aug. 1964.

The differences between the design of the second stage of the refuse power plant in Munich and the first stage are outlined. The refuse firing in the first construction stage was designed so that approximately 40 percent of the steam output is obtained from refuse, in the second stage the contribution of the refuse is only 20 percent. Instead of the two originally planned steam generators with approximately 32 tons per hour refuse throughput each, there will only be one with a throughput of 40 tons per hour. The third factor in which the second stage differs from the first one is that there is no separation in the former between the combustion chamber for refuse and powdered coal.

11638T

Angenend, Franz-Josef

**THE STATE OF REFUSE INCINERATION IN THE USA.** ((Der Stand der Mullveraschung in den USA.)) Translated from German. Brennstoff-Waerme-Kraft, 17(8):396-398, Aug. 1965.

The state of the refuse incineration industry in the United States is discussed on the basis of presentations made at the National Incinerator Conference held in New York, 1964. Covered are the planning of incineration units, storage, dumping slag utilization, furnace systems, cooling and flue gas utilization, purification of flue gases, e.g. by dust precipitation and elimination of air pollution. Settling chambers, wet scrubbers, cloth filters, cyclones, and electrostatic precipitators are discussed. Domestic incinerators are criticized as unsatisfactory, causing 25% of all complaints for excessive smoke and odor in New York. It is concluded that most existing refuse incineration plants are not substantially automated and require a large number of operating personnel. In most cases the purification of waste gases is not satisfactory. Maximum emission standards, and their variation in different cities are discussed. Refuse incineration and technology is probably functioning at a higher level in Germany than in the USA at the present time. It is emphasized that refuse incineration technology requires a larger amount of scientific research than it has been receiving in the past. Some novel developments, including a double mantle upright cylindrical combustion chamber, a rotating drum installation and a moving-grate firing installation (which is illustrated) are discussed.

11640T

Bachl, Herbert and Franz Maikranz

**INCINERATION OF REFUSE IN A HIGH-PRESSURE STEAM PLANT.** ((Erfahrungen mit der Verfeuerung von Mull in einem Hochdruck-Dampfkraftwerk.)) Translated from German. Energie, 17(8):317-326, Aug. 1965.

Refuse is used as a fuel in two high-pressure superheated steam boilers at the 'Nord' power station of the Munich municipal system. The boilers are designed for burning coal or refuse, either alone or in combination. The technical features of the plant are given in detail, including the site-map of the station, boiler design data, construction history 1961-65, firing mechanism, and experience in operation. The design and

operation of a refuse shed and crane are discussed, and experimental runs with coal and refuse firing are described. Refuse averaged 45-50% of ash and was found to contain only 1.64-2.48% of scrap metal. The storage bin and loading area did not attract rats or vermin. Refuse feeds of 25 tons/hr were achieved with a caloric output of 1200-1300 kcal/kg. The percentage of refuse in the overall operation will be about 35%. The refuse-generated power would have negative prices due to the city subsidies. The financial advantages would benefit the city administration and the government. Refuse combustion will supply about 10% of the total future power requirement of Munich. Air pollution is not discussed, except indirectly, in terms of the high combustion efficiency of the coal burned, and the presence of an electrostatic precipitator in the system.

11647T

Franz Fischer

**THE REFUSE INCINERATING PLANT IN VIENNA.** ((Die Wiener Mullverbrennungsanlage.)) Translated from German. Brennstoff-Waerme-Kraft, 16(8):392-396, Aug. 1964.

A plant designed for the incineration of 600 tons of refuse daily, and also capable of burning used oil, is described. Three steam generators produce a maximum of 15 tons of steam per hour for remote heating and power production. The plant design is illustrated and discussed in detail, including storage of the refuse, the slag generator, an electrical current generating plant, and a system for utilization and disposal of used oil from industrial plants. Air pollution aspects are mentioned only incidentally, in connection with flue-gas recirculation for control of combustion-chamber temperature. The gas is transported from an electrostatic filter through a mechanical flue gas purifier. The presence of large amounts of fly ash and the advantages of an angle-tube boiler for easy cleaning of heating surfaces are mentioned. The experiences gained during the first year of operation are also discussed.

11649T

W. Gruetsky

**HEAT TECHNOLOGICAL MEASUREMENTS IN A REFUSE INCINERATING PLANT.** ((Warmetechnische Messungen an einer Mullverbrennungsanlage.)) Translated from German. Tech. Ueberwach., (Duesseldorf) 4(6):211-214, June 1963.

Measurements conducted in an experimental refuse incinerating plant to establish the heat technological parameters that may serve as a basis for a larger project are reported. The following measurements were made: the refuse combusted and the amount of ash removed was weighed; the amount of fuel oil used; the amount of steam generated; the amount of cooling water used; the pressure at the steam outlet and the superheater; temperature; composition of the gas; SO<sub>2</sub> and SO<sub>3</sub> content of the flue gases; content of acetic acid and aldehyde; biological studies on the ash cooling water; moisture content of the flue gases; and special analysis of the ash including specific heat and calorific value of the ash. The efficiency of the refuse incinerating plant was 56.7 percent. For maintenance of purity of the atmosphere, the requirement is imposed on refuse incinerating plants that the flue gas after 1000 fold dilution as it is assumed to be at the exit of the smokestack must show only one-tenth of the maximum working site concentrations tolerated for acetic acid and formaldehyde. The measured corresponding values represented but fractions of the maximum permissible immission values.



11651T

Walter Hanstedt

**PLANNING OF REFUSE ELIMINATION AND UTILIZATION PLANTS IN THE RUHR AREA WITH EMPHASIS ON MAINTAINING THE PURITY OF THE AIR.** ((Planung von beseitigungs- und Verwertungsanlagen für Müll im Ruhrgebiet im Hinblick auf die Reinhaltung der Luft.)) Translated from German. Staub, 23(3):218-225, March 1963. 6 refs.

A working group comprising 22 townships was established in the German Ruhr area to develop and implement measures for refuse removal. Four possibilities of disposal are listed: the deposition of refuse in alternating layers with soil, composting of refuse, incineration combined with heat utilization, incineration without heat utilization. The advantages and disadvantages of these methods are discussed in detail, with special emphasis on air pollution by fly ash. Experience with a composting plant in Duisburg showed that for odor removal air coolers and scrubbers had to be installed. Finally a process was adopted which used chlorine dioxide for decomposing organic compounds. It is recommended that composting plants be located at least 500 m from residential areas. In refuse incineration it is shown that there is a difficulty in finding markets for the heat produced. An example of a large incineration plant with heat utilization in Karnap is given and it is emphasized that incinerators can be used in combination with peak power plants. Experience with a small incinerating plant without heat recovery is also described.

11655T

C. Kachulle

**REFUSE INCINERATING PLANTS WITH OR WITHOUT HEAT UTILIZATION. A MAIN SUBJECT OF THE THIRD CONFERENCE OF THE INTERNATIONAL WORKING GROUP FOR REFUSE RESEARCH, TRIENT, 1965.** ((Abfallverbrennungsanlagen mit oder ohne Wärmenutzung. Ein Hauptthema des dritten Kongresses der Internationalen Arbeitsgemeinschaft für Müllforschung in Trient, 1965.)) Translated from German. Brennstoff-Wärme-Kraft, 17(8):391-395, Aug. 1965

Several refuse research topics were discussed, including refuse incineration with heat utilization for steam generation. A cost comparison of a refuse incineration plant in Issy-les Moulineux which has four furnaces with a capacity of 17 tons/hr each, showed that income from the sale of electric power and steam exceeds the operating expense. In Glasgow, Scotland, it was found that the electricity generated in refuse combustion cannot be sold in Great Britain on a continuous basis. Another topic discussed was a central refuse disposal plant installed as additional incineration units in existing power plants. Such an installation is being operated in Goldenberg, near Cologne, Germany. The operating capacity of this unit is 1,026,000 tons/year. The planning and design for the Goldenberg plant are illustrated and discussed in detail, including refuse transportation from a wide area on compactor trucks with removable bodies, rubbish and scrap processing, moving grate incineration, and refuse storage in surrounding mines. The advantages of large central incineration plants are discussed. No air pollution control details are given.

11657T

G. Meyer

**DESIGN AND OPERATION OF A MS COMBUSTION CONE PLANT WITH REFUSE.** ((Aufbau und Wirkungsweise einer MS-Brennkegelanlage mit Müllzerkleinerung.)) Translated from German. Aufbereitungs-Technik, No. 3, pp. 135-138, 1964.

The design and operation of a MS combustion cone plant including the crushing installation for refuse are described. The unsorted refuse is dumped by truck into a refuse bin where it is dried. At the bottom of this bin, a combined discharging and crushing installation is provided which reduces the refuse to a desired size (pieces whose edges are 40 cm long) and discharges the material from the bin. By means of a steel plate conveyor the material is fed into the combustion cone housing and thrown on to the combustion cone grate. With plants for a throughput of 1500 kg per hr of refuse, the combustion cone has a maximum diameter of approximately 3.2 m and rotates with a speed of 30 to 40 cm per minute relative to the maximum circumference. The ignition of the material is effected by a Schoppe burner operated optionally with oil or gas. The design and control of the blowers in the system, calculated to prevent the emission of odoriferous or harmful gases, is discussed and illustrated.

11666T

K. A. Wuhmann

**POSSIBILITIES AND LIMITS OF WASTE INCINERATION.** ((Möglichkeiten und Grenzen der Müllverbrennung.)) Translated from German. Aufbereitungs-Technik, 5(9):506-507, Sept. 1964.

Several lectures presented at the Third Waste Technological Colloquium which considered the technological and practical aspects of the process of waste incineration are summarized. The lectures included the technical basis of waste incineration, various incineration systems and the problems concerning fireproof materials, and the experiences in the Stuttgart incineration project. It became apparent that the problem of selecting a suitable incineration system is not yet solved, especially for medium sized plants which still face extensive development and expansion. Aspects discussed include the ignitability of the refuse, transportation to the plant and weighing, the refuse bin, handling of the fire, removal of the slag, and selection of grates. Legal requirements for air pollution control are mentioned and some data given e.g. a limitation of 0.4mg/cum of SO<sub>2</sub> emission.

11803

Fuller, Louis J., Ralph E. George, and John E. Williamson

**SOME OBSERVATIONS ON AIR POLLUTION IN NEW YORK CITY: A REPORT TO THE MAYOR.** Los Angeles County Air Pollution Control District, Calif., 30p., Jan. 17, 1966.

Air pollution in New York City has attained serious proportions as a result of the incineration of rubbish and garbage, combustion of fuels, motor vehicle emissions, and the growth of industries, both within the city and in adjacent areas. Precise information on the quantities of pollutants emitted by each source are needed. However, incineration and fuel combustion are so serious that abatement measures cannot await further studies. Rapid and substantial improvements in rubbish and fuel combustion pollution should be achieved by applying known techniques. Rubbish disposal pollution can be relieved by substituting sanitary landfills for incineration; installing baghouse type control devices on municipal incinerators; replacing single chamber and flue-fed incinerators with gas-fired multiple-chamber incinerators; and permitting the use of domestic garbage grinders. Fuel combustion pollution can be relieved by substituting natural gas for coal and oil; prohibiting the use of coal and grade No 6 residual fuel oil by Consolidated Edison; requiring the installation of two-stage combustion controls on the power company's fossil fuel-fired boilers; and prohibiting further installation of fossil-fired

power plants in or near the city. Specific information must be obtained on the nature and quantity of pollutants from all sources. In addition, the behavior and motion of pollutants in the atmosphere must be determined. To accomplish these objectives, emission inventories and a comprehensive meteorological survey should be undertaken and a comprehensive air monitoring program instituted. (Author summary modified)

11934

Rasch, R.

**FURNACE SYSTEMS FOR REFUSE INCINERATION.** (Ofensysteme fuer die Muellverbrennung). Brennstoff-Waerme-Kraft, 16(8):376-382, Aug. 1964. 11 refs. (Presented at the 3rd Muelltechnischen Colloquium of the TH Stuttgart, Feb. 21, 1964.) Translated from German. Iron and Steel Inst., London (England), British Iron and Steel Industry Translation Service, 25p., May 1966.

Various furnace systems for refuse incineration are described and classified in terms of size and type of combustion grating. Grating systems considered are the fixed-grate, the movable grate without agitation, and the agitated grate. Grateless systems are also reviewed; these include the Riepel-Scherer-Ridl Process with slagging, the flame chamber process with slagging, and the Stauff Process with combustion in suspension. It is recommended that special quality liners be provided for combustion chambers because of excessive wear caused by refuse burning as compared with coal. A limit of 100,000 kcal/cu m is set for the fire chamber load. The use of hot waste gases to pre-dry refuse and to reduce combustion chamber temperature is mentioned. Waste gas temperature must be reduced to 350 C to assure proper induced draft and to protect gas purification equipment. Heat recovery in the form of steam has limited economic importance. Ash removal and post-sintering of refuse ash to produce construction material are also discussed briefly.

11939

Nuber, K.

**GARBAGE BURNING ACCORDING TO THE DUSSELDORF SYSTEM.** Aufbereitungs Technik, no. 5:199-202, 1962. 6 refs. Translated from German. 11p.

An experimental refuse incineration plant is constructed to permit refuse to be constantly loosened, turned, and moving during the incineration process. This allows the plant to handle various types of garbage at any one time and ensures that every single piece finally reaches ignition temperature. The method utilizes a grate construction from large, slowly rotating rollers that are arranged in a series. Air for combustion enters the rollers axially, thus cooling them. The air supply can be regulated for every roller individually. A feed car pushes the garbage in layers into a combustion chamber where it passes from one roller to another. During the process, refuse is turned over several times and loosened again and again. To favor drying and ignition processes, the stream of hot gases is directed against the flow of the garbage. The last roller discharges the burnt residues on a traveling grate. The plant has been operating for one year. During this time, it has handled one-third of all refuse collected in Duesseldorf. The required temperature for the process is 900-100 C, well above limits of odor perception. The ashes that remain are sterile and contain practically no fermentable substances. When graded, they can be used for road construction and similar purposes.

11940

Eberhardt, H. and H. Weiland

**EXPERIENCES WITH THE NOVEL TILTING-STAGE-GARBAGE INCINERATION METHOD IN THE COMPOSTING PLANT AT STUTTGART-MOEHRINGEN.** Aufbereitungs-Technik, no. 11:490-494, 1962. Translated from German. 13p.

A tilting-stage garbage incineration plant is described in detail. The tilting-stage grate consists of 12-20 turning, arc-shaped rows of grate rods. By successive tilting of the different rows of grate rods, the garbage is passed downward. The base of the furnace is 6.5 times 2.5 m; its height is 9.9 m. According to the kind of garbage to be processed, this plant can handle up to 220 kg of garbage per hour, with complete burning of the garbage slag. Lack of homogeneity of raw refuse is often a cause of difficulty in incineration. In the plant described, a coarse chopping process with simultaneous mixing of the raw refuse prior to its introduction to the furnace facilitates incineration and increases the performance of the incinerator. A disintegrator is used with advantage for the chopping and mixing. At waste gas temperatures of about 350 C, the values of dust emission from the smoke stack are 0.2-0.5 g/cu m.

11961

Joachim, H.

**THE REFUSE INCINERATION PLANT OF THE MUNICIPALITY OF GLUECKSTADT IN HOLSTEIN.** Aufbereitung-Technik, no. 3:126-129, 1964. Translated from German. 10p.

The construction of a refuse incineration plant with a capacity sufficient for a town of 14,000 residents is reviewed. Because of the dimensions and peculiarities of small-town refuse, a multiple zone pushing grate was chosen as the main component of the plant. The grate has a capacity of 3.28 t/hr at a volumetric weight of 463 kg/cu m. Ash and sludge in the residue is discharged through a wet ash removal plant, while scrap metal is separated by a drum magnet and compacted to 1:5 to 1:13. The slag and ash, free from scrap metal, can be used as fill and in general road construction. The scrap metal is returned to the steel industry. Combustion temperatures are between 750 and 900 C. However, transitory increases up to 1200 C must be absorbed. These peak temperatures occur when refuse from local industries (paper, paint) is included. The bunker space in the plant has refuse storage capacity sufficient for one week's refuse from all sources. Plant operations are controlled from a central room, so it is possible to operate the plant with two persons. For utilization of waste heat, the refuse incineration plant is provided with the sludge-drying plant.

11962

Gerhardt, R. and H. Ermer

**MODEL INVESTIGATION OF THE OPTIMAL LAYOUT OF REFUSE INCINERATION PLANTS FOR SMALL AND MEDIUM-SIZED TOWNS ON THE BASIS OF THE EXAMPLE OF THE PLANT AT NEUSTADT IN HOLSTEIN.** Aufbereitungs-Technik, no. 3:110-119, 1964. 3 refs. Translated from German. 29p.

A refuse incineration plant without heat utilization is under construction in a town of 15,000 inhabitants which has wide seasonal variations in the amount of refuse to be incinerated. In the summer, refuse production per day is 100 cu m or 470 kg per inhabitant annually. During the remainder of the year, refuse production decreases to approximately 190 kg per inhabitant annually. The incineration portion of the plant is designed so that, during an 8-hr operation per day, the plant



can handle the total refuse produced in the summer months. The capacity per hour of the plant will be 3.75 tons of refuse. The furnace chosen has a nominal capacity per hr of 4.72 tons. The plant will have a reserve capacity for refuse from parties who operate their own refuse collection systems and from industrial establishments. The plant is divided into two parts: the heavy supporting structure containing a refuse bin with a capacity of 320 cu m refuse (corresponding to a maximum refuse production of three days) and furnace feeding equipment. Refuse dumped into the refuse bin is transported by a crane to the feeder tunnel of the furnace and then by a hydraulically activated feeder device to the incineration grate of the furnace. A tilting grate is used. Air for burning is sucked from the refuse bin by an undergrate blast. Ash and slag are mechanically removed from under the grate and discharged through an underwater scraper. The incineration process can be varied according to the characteristics of the refuse. For instance, if the refuse burned has a low heating value, an oil burner can be used. Investment and operating costs for the incineration plant, heat power plant, and hot water and heat supply plant are discussed in detail.

11963

Block, H. and A. Duhme

**REFUSE INCINERATION ACCORDING TO THE VOLUND SYSTEM.** *Aufbereitungs-Technik*, no. 3:120-125, 1964. 2 refs. Translated from German. 17p.

With the Volund continuous incineration system, the furnace plant is fully mechanized from the refuse feeding point to the slag discharge. The throughput speed of the refuse can be adjusted for individual zones. Drying the refuse with a widely fluctuating moisture content and its ignition is effected on grates designed as stokers with reciprocating grate bars. Drying the refuse in the preheated air or hot waste-gas current, in combination with the reflected heat from the firing chamber, is intensive and permits the processing of very moist garbage without interfering with the smooth operation of the system. From the ignition grate, the garbage reaches the rotating drum, which is slightly inclined toward the longitudinal axis. The drum, which as a fire-resistant lining, rotates at an infinitely variable speed according to the furnace speed. The combustible components remaining in the refuse are burned as much as possible by the continuous churning and by the addition of high-temperature air to the drum wall. Additional heat is supplied by the flue gases. At the end of the drum, slag is removed by a wet-type installation. Volund plants are highly insensitive to fluctuations of heating value and load. To help solve the problem of sewage sludge destruction, a plant can be equipped with a parallel-operating sewage sludge treatment plant. For drying, waste gases from the refuse incineration plant can be used. The mixture of waste gases and vapors is later recycled to the main gas current from the refuse incineration to destroy aromatic substances. The dried sewage sludge can then be burned in the incineration plant.

11968

Bachl, Herbert and Franz Maikranz

**FIRING REFUSE IN A HIGH-PRESSURE STEAM PLANT.** (*Erfahrungen mit der Verfeuerung von Müll in einem Hochdruck-Dampfkraftwerk*). *Energie* (Munich), 17(8):317-326, 1965. Translated from German. 26p.

The problem of refuse incineration and refuse utilization was solved in a new way in the Nord power station of the Munich municipal power system. Refuse is used as a fully equivalent fuel in two high-pressure superheated steam boilers. The boilers are designed for firing coal and refuse alone or in com-

bination. When coal and refuse are combined, 60% of the full-load heat is supplied by coal and 40% by refuse. When only refuse is fired, reduced steam pressures and steam temperatures are used without generation of electricity. The installation can also be converted to gas firing or oil firing. In the pulverized coal-firing boilers, refuse is burned on Martin refuse grates located under the refuse flue gas pass. At full load, a boiler efficiency 92.5% is guaranteed for all-coal firing; efficiency for combined operations is 85%. The annual capacity of the boilers is expected to be about 420,000 t/yr of refuse. At an average refuse heating value of about 1200 kcal/kg, about 500,000 Gcal/hr is supplied the power station by refuse. In coming years, the plant is expected to meet about 10% of Munich's power requirements. The boilers and auxiliary plant equipment are described in detail.

11969

**TRASH INCINERATION PLANT FOR DARMSTADT.** (*Muellverbrennungsanlage fuer Darmstadt*). *Brennstoff-Waerme-Kraft*, 16(8):408, Aug. 1964. Translated from German. 1p.

Two steel-tube boilers, each of 25 tons/hr steam capacity at 48 excess atm and 450 C are being furnished for a trash incineration plant for the city of Darmstadt. The trash incineration grates are designed for a trash throughput of 200 tons/day. The trash does not require preliminary pulverization or sorting. At about 1000 C incineration temperature, all possible putrefaction agents are destroyed; the ashes are therefore sterile and odorless. The dust is collected by filtering equipment to prevent pollution in the vicinity of the plant.

11971

Ferber, Michael

**TRASH INCINERATION AND AGGLOMERATING PLANT IN BERLIN.** (*Muellverbrennungs- und -sinteranlage in Berlin*). *Brennstoff-Waerme-Kraft*, 16(8):409, Aug. 1964. Translated from German. 1p.

An incineration plant for city trash and some industrial refuse, scheduled for completion in Berlin-Ruhleben in 1968, is described. The refuse, together with heating slag, fly ash from power plants, and sludge from a neighboring clarification plant are processed in an agglomerating belt installation into admixtures for concrete. Excess heat will be used for steam at 24 excess atm, 430 C for municipal heating purposes. When completed, a daily maximum of 2000 tons can be processed with a daily agglomerate production of about 1000 tons. This will correspond roughly to half the total trash output of the entire West Berlin metropolitan area. A population of 2.2 million, with an annual trash load of about 3.3 million cu m (about 870,000 tons), is projected after 1972.

11972

Palm, R.

**FUNCTIONS AND COMPUTATION DATA OF REFUSE INCINERATORS.** *Energie* (Munich), 17(12):539-542, Dec. 1965. 2 refs. Translated from German. 13p.

Design and evaluation factors for the firing chamber of refuse incinerators are reviewed. This chamber mixes both the combustible gases developed over the grate and the flying coke carried by them with the excess of air flowing through the grate, and burns the mixture. The chamber is limited by the grate, a short feeder vault, and a longer, vertical recycling vault; the flame must reflect heat back to the grate by the vaults. The coarse dust from refuse incinerators should at least be trapped, and particular attention must be paid to cleaning fly ash from the heating surfaces of the incinerator equipment.



## MUNICIPAL INCINERATORS

Grate widths are given for small installations; small grates are often troubled by slag, and therefore grate size should not be less than 1.20 m., even if loads are small. On the other hand, oversize grate widths result in a slower grate movement and less of a stoking effect. In a discussion of thermal stress of the firing chamber, the method for calculating thermal efficiencies in the presence of different types of refuse is developed, and several examples are worked out.

12441

Construction Research and Development Corp., Los Angeles, Conrad Engineers Div.

**INCINERATORS.** In: Tenement Refuse Disposal Systems and Artificial Illumination of Communal Areas. Contract FH-940, Section 2, 98p., March 1967. 56 refs. CFSTI: PB 180879

Despite the advantages of incinerators in a waste burning system, their contribution to air pollution, usually because of incomplete combustion, has led to increased legislation regulating their operation and performance. Incinerators can be built that do not emit pollutants; to accomplish this, any given incinerator should be designed for its particular application. The design requirements of installations for single dwelling or small apartment buildings, rehabilitated tenement buildings, and square blocks of buildings are briefly discussed. Four appendices are included: the first and second present the portions of New York City and Los Angeles County air pollution control legislation pertinent to incinerators; the third is a reprint of Multiple Chamber Incinerator Design Standards for Los Angeles County by staff members of the Los Angeles County Air Pollution Control District; and the fourth is the text of a study entitled 'Criteria Used for Upgrading Existing Apartment House Incinerators in the City of New York'.

13112

Beck, Horst

**AIR POLLUTION PROBLEMS AT INCINERATORS WITH CAPACITIES UP TO 5 TONS/HR.** (Probleme der Luftreinhaltung bei Abfallverbrennungsanlagen mit Durchsatzleistungen bis zu 5 t/h). Text in German. Energie Tech., 21(6):207-210, June 1969.

With the increasing use of incinerators for waste disposal, regulations concerning the emission have become stringent. Ver. Deut. Ing. standard 2301 (Feb. 1967) calls for a reduction of stack emission of particulate matter to 200 mg/cu m for moist flue gas (with a CO<sub>2</sub> content of 7%) from incinerators with a capacity of less than 1.5 t/hr. Incinerators with a higher capacity are to be equipped with the most recent dust collectors. Efficient flue gas cleaning depends very much on the selection of a suitable cleaning facility. Many factors such as grate construction, size of the combustion chamber, capacity, composition of the waste material, heating value, excess air, and dust concentration of the dirty gas ought to be considered. If wet dust collectors are used, waste water purification facilities must be available. Cyclones and multiclones can be used presently only with incinerators whose flue gases carry low dust concentrations. The advantage of such dust collectors is their small size. Electrostatic precipitators are gaining increasing importance, particularly when operated in connection with a multiclone. But the newest and most suitable dust collectors for the present composition of flue gases are probably bag filters. Europe's most modern incinerator, erected in Berlin and inaugurated in 1968 (capacity of the plant is 750 kg/hr), has been equipped with such a facility after satisfactory results had been gained with a bag filter in Switzerland. Depending on the need, such filters can be equipped with silicon-treated glass fiber bags of tubular shape or with synthetic fiber bags.

Periodically, the tubes are shaken to dislodge the dust and cause it to fall into the collecting hopper. Such filters separate dusts which are in the submicron range.

13622

Zurich, R. Tanner

**OPERATING RESULTS OF THE INCINERATOR OF THE CITY OF LAUSANNE.** (Betriebsergebnisse der Muellverbrennungsanlage der Stadt Lausanne.) Translated from German. Brennstoff-Waerme-Kraft (Duesseldorf), 20(9):430-432, 01968.

The performance of the Von Roll incinerator in Switzerland is discussed based on data compiled for the years 1959 to 1967. Emphasis is placed on investment and operating costs, design (flue gases are cleared using electrostatic precipitators), operating results, and personnel. It is concluded that although the main task of an incinerator is the hygienic disposal of waste, such a plant should operate with enough safety margin to avoid long interruptions. The Lausanne plant owes its success exclusively to the standby units and to its design, which makes monitoring during operation easy for the personnel.

14168

Ishii, I.

**INCINERATOR. 2. PROBLEMS ON DESIGN.** (Gomi shokyakuro ni tsuite (2) Sekkei jo no shomondai). Text in Japanese. Netsu Kanri (Heat Engineering) (Tokyo), 20(5):7-12, May 1968. 8 refs.

Design of an incinerator was based on (1) estimation of the character of household trash and garbage, (2) the burning ratio between percentages of household trash and garbage, (3) amount of air in trash, (4) furnace volume, and (5) chimney pressure drop. Trash is expressed at the point of a triangle coordinate whose elements are water, ash, and coal. Burning ratio is derived from elliptical equations whose coordinates are household trash and garbage. The amount of air is assumed to be 0.5 cu nm/kg for household trash and 2.9 cu nm/kg for garbage. Furnace volume is expressed by (burning rate) x (lower heat of generation)/(heat generation in the furnace). Pressure drop is the summation of that of the chimney and of the trash layer. Chimney height is directly proportional to the pressure drop and inversely proportional to gas temperature. Chimney size is determined by Kento's equation.

14367

Kaiser, E. R.

**THE INCINERATION OF BULKY REFUSE. II.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 129-135. 5 refs. (May 5-8).

Conventional incinerators are not designed to cope directly with logs, tree stumps, branches, truck tires, demolition lumber, furniture, mattresses, pallets, and the like. Landfill space is limited and must be conserved by reduction in the volume of refuse. Tests are described which show the practicability of hearth-type furnaces for the incineration of bulky refuse. The oversized waste is charged by tractor into the furnace. Burning rates average 18 lbs/hr/sq ft of refractory hearth area. Smoke, produced by the presence of hydrocarbons and the rapid rate of devolatilization of part of the waste, is burned out in a secondary chamber with excess air, turbulence, and time. Fly ash emission is kept low because of minimal flow of underfire air. Tests of two primary chambers of a bulk-charge furnace 20 times 10 times 12 ft high are given and the findings are coordinated with guidelines to designers.

Also shown are proposed designs for incineration of 2 to 20 tons per hour.

14442

Kuhlmann, A.

**TOWNS AND COMMUNITIES CANNOT IGNORE THE NECESSITY OF RUBBISH INCINERATION.** (Städte und Gemeinden dürfen sich der Notwendigkeit zur Müllverbrennung nicht entziehen.) Text in German. Brennstoff-Wärme-Kraft, 20(9):405-408, Sept. 1968.

From the point of view of hygiene, the use of dumps is indefensible, while rubbish incineration using modern techniques is both satisfactory and economically feasible. Graphs showing the annual total weight and volume of rubbish produced per inhabitant in the cities of Amsterdam, Stockholm, West Berlin, Düsseldorf, Hamburg, Hannover and Frankfurt am Main are given. As an example, a graph showing the heating values of rubbish in the years 1955 to 1964 Bern, Switzerland exhibits a strongly rising trend. The present state of rubbish combustion is discussed. The initial and operating costs are considered in detail and a numerical example of the rubbish combustion plant costs for a city of 850,000 inhabitants is given.

14923

Smith, Russell A., Lee L. Wikstrom, and Arrigo A. Carotti

**AIR BORNE EMISSIONS FROM MUNICIPAL INCINERATORS. SUMMARY REPORT OF STATE OF KNOWLEDGE, RECOMMENDATIONS FOR FURTHER STUDIES AND AN ANNOTATED BIBLIOGRAPHY.** New York Univ., University Heights, N. Y., Chem. Eng. Dept., Contract PH 86-67-62, 35p., May 1967. 56 refs.

Studies of emissions from municipal incinerators were reviewed and found to be relatively limited in number as well as in scope. Some are concerned only with particulate, CO<sub>2</sub>, CO, H<sub>2</sub>O, O<sub>2</sub>, and N<sub>2</sub> emissions while others are concerned with the parameters and the parameters influencing the quantity of emission. In general, these analyses were conducted during normal, steady state incinerator operating conditions. More detailed identification and quantitation were restricted to particulates and hydrocarbons. New York City area studies seemed particularly few in numbers. The following recommendations for future studies are made: sample and analyze stack discharge from municipal incinerators in the New York City metropolitan area; determine the rate of discharge of specific chemicals over a 12-month period, with emphasis on toxic substances; determine the rate of discharge when the incinerator is operated at design capacity and/or at capacity loading that meets local air pollution control requirements; and determine variations in general composition. A brief summary paragraph is given with most of the references.

14972

Smith, David B. and David H. Scott

**COMPREHENSIVE AIR POLLUTION CONTROL PLANT. PART ONE. DATA SUMMARY. AIR POLLUTION AND METEOROLOGY.** David B. Smith Engineers, Inc., Gainesville, Fla., HUD Proj. FLA. P-65, 38p., July 1968. 23 refs. CFSTI: PB-184678

A background study of air pollution in Palm Beach County identifies and locates the county's major emission sources. Climatological and meteorological conditions which increase the severity of pollution are described. It was found that common air pollution complaints to the county involve commercial incineration in close proximity to residential areas, caused by careless operating procedures. Improperly operated, the 74 ap-

proved small commercial incinerators produce soot, fly ash, and smoke. Seven sugar mills and two major fossil-fuel electric generating plants emit significant quantities of smoke and related pollutants due to either improper operation, low grade plant fuel, or can field burning with uncontrolled emissions. Pratt & Whitney Aircraft emits atmospheric pollutants on an occasional short-term basis. Burning of junked automobile hulks and production of asphalt contributes to the emissions. Only in the Pahokee-Belle Glade area do dustfall measurements exceed a median residential-commercial threshold concentration of 14.4 tons/square mile/month under average conditions. All sampling points experience greater maximum dustfall concentrations except Royal Palm Beach. Dustfall concentrations in Riviera Beach, West Palm Beach, Palm Springs, Delray Beach, Boca Raton and the Pahokee-Belle Glade area exceed the standard concentrations for strictly residential areas. Salhaven, Cross State, Boca Raton Rubbish, Lake Park, Pahokee North, and Belle Glade solid waste disposal sites practice open burning of wastes. Uncontrolled burning at some of these sites greatly reduces night time visibility along major transportation arteries including the Sunshine State Parkway. (Author abstract modified)

16254

**EFFECTS OF VARIATIONS OF THE WASTE COMPOSITION ON DESIGN PARAMETERS OF INCINERATORS.** (Die Auswirkungen von Schwankungen der Müllbeschaffenheit auf einige Konstruktionsparameter von Müllverbrennungsanlagen). Brennstoff-Wärme-Kraft, 20(9):428-429, 1968. 1 ref. Translated from German. Franklin Inst. Research Labs., Philadelphia, Pa., Science Info. Services, 6p., Sept. 25, 1969. (Presented at Winter Annual Meeting of the American Society of Mechanical Engineers, Pittsburgh, Pa., 1967.)

A computer program was developed to find the limits within which the waste composition may change and to find the effects of the changes on the various parameters. The program is executed with the following values: upper heating value from 2225-4450 kcal/kg, carbon from 24-405%, hydrogen from 3.5-7.5%, oxygen from 20-30%, water from 11-30%, incombustible material from 11-22.5%, and carbon/hydrogen ratio from 10.8-24. It was shown that the heating value increases with increasing content of free hydrogen. If the waste composition and heating value, air surplus, and heat loss are given, the combustion products at a capacity of 900 kg/h can be found with the computer program. The specific heats and enthalpies can be found and a heat equation can be established to determine the equilibrium gas temperature. The computer program also helps to find the amount of water required for cooling flue gases to 540, 400, 260, 120 C, or to saturation. It also determines the mass and volume flow at every important point in the circulation. All calculations include a certain assumed percentage of incombustible material. An air surplus from 40-300% and a heat loss from 2-60% of the entire released heat are included in the input data. With this program, 2310 various cases can be computed and 70,000 individual data for 21 different waste compositions can be obtained. By feeding the results of analysis of the waste composition and its presumable variation over a certain period into the computer, all parameters essential for the sizing of the individual parts of the incinerator within a certain determined range can be found.



16514

National Air Pollution Control Administration, Raleigh, N. C., Div. of Abatement

**INTERIM GUIDE OF GOOD PRACTICE FOR INCINERATION AT FEDERAL FACILITIES.** NAPCA Pub. AP-46, 94p., Nov. 1969. 19 refs.

This guide is to be used by Federal Agencies in selecting incinerators for burning the following wastes: highly combustible mixtures, e.g., paper, cardboard, wood, floor sweepings, plastic, and rubber, containing 10% moisture and 5% noncombustible solids; combustible mixtures of paper, cardboard, wood, foliage, floor sweepings, and restaurant wastes containing 25% moisture and 10% noncombustible solids; approximately even mixtures of rubbish and garbage containing up to 50% moisture and 7% incombustible solids; and human and animal remains containing up to 85% moisture and 5% incombustible solids. The information presented applies to incinerators with a burning capacity of 2000 pounds/hr or less of general refuse and up to 200 pounds/hr of pathological wastes. Multiple-chamber retort or multiple-chamber in-line incinerators are specified for general refuse; multiple chamber retort incinerators, for pathological refuse. Any incinerator of more than 200 pounds/hr capacity must be equipped with specified scrubbers or scrubbers of equivalent efficiency. Testing will not be required for incinerators and incinerator-scrubber combinations built as recommended. Multiple-chamber incinerators conforming to Incinerator Institute of America Standards will be accepted as alternate incinerators if their emission levels are determined by prescribed tests.

16710

**POLLUTIONLESS REFUSE INCINERATION.** Brit. Chem. Eng., 13(12):1653, Dec. 1968.

A continuous closed system, achieving complete combustion of refuse without atmospheric pollution, is described. In this system, a unique grate design ensures efficient transport of the burning refuse and creates maximum disturbance and aeration of the furnace bed. Operation is automatic, with minimum labor requirements, and unit capacities vary from 60 to more than 900 t/d.

16869

Kaiser, Elmer R.

**SUCCESSFUL INCINERATORS ARE NOT CHEAP.** Power, 113(9):78-79, Sept. 1969.

Whether incinerators only dispose of refuse or generate steam as well, careful design is needed to make them acceptable to their users and to the community. The sizing, location, and control of air jets to promote complete combustion, corrosion, and stack height are among the problems that must be considered in incinerator design. A large multipurpose incinerator plant constructed in Stamford, Conn. is described briefly.

17243

KUSUMOTI, MASAYASU

**SOME PROBLEMS IN REFUSE DISPOSAL.** (Haibutsu shobun no mondaiten). Text in Japanese. Yosui to Haisui (J. Water Waste), 11(8):619-621, Aug. 1, 1969.

Disposal of refuse, solid or liquid, does not imply complete solution of the refuse problem, although some refuse is partly reduced to energy by incineration and partly dispersed to the atmosphere in an aerosol state. Human productive activities are closely linked to the metabolic processes by which nature provides raw materials and other substances for consumption,

and as long as men remain within the metabolic cycle the balance between nature and productive activities is maintained. In highly industrialized societies, this equilibrium is lost. For example, in the process of pulp manufacturing, nearly 4 tons of refuse is processed per 1 ton pulp, while in the second process of paper production, 13% of refuse is produced per total amount of pulp. What is finally collected as paper is about 40%; the remaining 60% is refuse. The concept of refuse disposal as a transitional process in which refuse is conveyed to the cycle of metabolism and then returned to nature may not be a reliable one. It appears more promising to dump refuse in the ocean or to utilize it for land reclamation by composting or fertilization even though these solutions involve problems of large scale collection and transportation. Studies bearing on technical aspects of composting and land reclamation are sufficiently developed to suggest that composting is the most practical countermeasure for refuse disposal.

17462

Murakami, M., T. Kawashima, and K. Kamitsu

**INCINERATION PLANT AT ISOGO IN YOKOHAMA CITY.** (Yokohamashi seisokyoku isogo kojo ni tsuite). Text in Japanese. Kukichowa Eisei Kogaku (J. Japan Soc. of Heating Air Conditioning Sanitary Engrs.), 44(2):131-138, 1970.

The design and operation of the recently constructed Isogo incineration plant is presented. The plant site area covers 13141 sq m, of which buildings occupy 7330 sq m. The plant is composed of three basements, five floors, a waste dumping building, a charging building, furnace building, central building, and other adjoining buildings. The average yearly incineration capacity is 300 t/24 hrs; the maximum capacity of 450 t/24 hrs is designed to meet seasonal increases in refuse. The plant is characterized by a sanitary working environment and the application of modern technology. The quantity of smoke dust emitted is less than 0.1 g/cu Nm due to the use of multicyclone and electric dust collectors. Effective smoke dispersion is promoted by a chimney height of 85 m; emission speed is more than 20 m/s. An airtight pit chamber prevents the discharge of odors. Waste water is chemically treated to meet water quality standards. At night, noise is suppressed to less than 50 phon. Furnace operations are automated and, like other proceedings, observed on television sets in a control room. Furnace rooms are ventilated 20 times/hr and other rooms between 10 and 15 times/hr. Surplus steam from waste heat in boilers is utilized for a sludge digestion tank and surplus gas, mainly methane, as a subsidiary fuel. The first floor of the plant is 5 m higher than the average tide level of Tokyo Bay.

17552

Hansen, Erwin G., P. E. Rousseau, and Henri Rousseau

**AN ENGINEERING APPROACH TO THE WASTE DISPOSAL CRISIS.** Combustion, 41(9):8-13, March 1970.

Conventional incineration plants in the United States have used a refractory type incinerator with a waste heat boiler installed in the flue outlet. Because of problems of maintenance, corrosion and slagging, and plugging of gas passages, this arrangement has been totally abandoned in European practice. As in the Issy-les-Moulineaux plant southwest of Paris, the incinerator boiler and furnace must be an integral unit. At the French plant, refuse is, in effect, burned in the furnace of a water-wall type boiler. The plant has four units, each designed to burn 39,600 lb of refuse an hour. In operation, collection vehicles discharge refuse to a pit having a two-day collection capacity. The pit is maintained under a negative atmospheric



pressure with all combustion air being drawn from the pit. Consequently, no dust spreads to the outside. Wastes are transferred by cranes from the pit to furnace charging chutes. Each furnace contains a Martin type stoker which provides a continuous tumbling of refuse through alternating movement of fixed and mobile bars. Ashes fall by gravity into a water trough from which they are discharged onto a belt conveyor. On leaving the boiler, combustion products pass through electrostatic precipitators with an efficiency of 98%. As a result, smoke emissions from the plant are rarely visible. Steam generated by the boilers is discharged to a back-pressure turbine where it is expanded to approximately 285 psi. This steam is sold to the heating company which serves the center of Paris. In 1967, the plant sold 1,100,000 lb of steam and generated 75,000,000 kw hours of electricity. The incinerated refuse, which contains only 0.1% putrescible matter and 3% unburned carbon (including fly ash), is also sold, generally for road construction. The plant was constructed in 1962 at a cost of \$23,000,000. In 1967, operating costs were \$1.46 a ton after the sale of steam, electricity, and residue.

17604

Stahl, Quade R.

**PRELIMINARY AIR POLLUTION SURVEY OF SELENIUM AND ITS COMPOUNDS. A LITERATURE REVIEW.** Litton Systems, Inc., Silver Spring, Md., Environmental Systems Div., Contract PH 22-68-25, NAPCA Pub. APTD 69-47, 76p., Oct. 1969. 135 refs. CFSTI: PB 188077

The literature on the human and animal effects, sources, abatement, economics, and methods of analysis of selenium and its compounds as air pollutants is reviewed, with an appendix of tabular material from selected references. Selenium compounds in the atmosphere are known to cause irritation of the eyes, nose, throat, and respiratory tract in humans, and, under conditions of prolonged exposure, gastrointestinal disorders. In animals, there are indications that selenium ingestion may cause cancer of the liver, and it is known to produce pneumonia and degeneration of liver and kidneys. Although no studies were found on the effects of atmospheric selenium on plants, species which are classed as primary indicators or secondary selenium absorbers are discussed. Sources of atmospheric selenium include combustion of industrial and residential fuels, refinery waste gases and fumes, and incineration of wastes including paper products which contains as much as 6 ppm selenium. Little data is available on concentrations of selenium in the air; one report indicated an average value of 0.001 microgram/cu m in the vicinity of Boston, Mass. Electrostatic precipitators and water scrubbers are effective in controlling emissions of selenium in industrial operations. No information has been found on the economic costs of selenium air pollution, or on the costs of its abatement. Methods are available for the analysis of selenium in the atmosphere, including neutron activation analysis and colorimetry. (Author abstract modified)

17610

Miner, Sydney

**PRELIMINARY AIR POLLUTION SURVEY OF AMMONIA: A LITERATURE REVIEW.** Litton Systems, Inc., Silver Spring, Md., Environmental Systems Div., Contract PH 22-68-25, NAPCA Pub. APTD 69-25, 39p., Oct. 1969. 79 refs. CFSTI: PB 188082

Ammonia is a natural constituent of the atmosphere, but exists in concentrations below the level that is hazardous to humans, animals, plants, or materials. High concentrations of ammonia gas are corrosive to mucous membranes; can damage the eye,

throat, and upper respiratory tract; and can produce residual damage and even death in humans and animals. High concentrations are also toxic to most plant life and corrode metals. Almost all of the ammonia in the atmosphere is produced by natural biological processes, largely from the decomposition of organic waste material. Ammonia produced by industry and as a result of urban activities, though of lesser importance, can be a factor in air pollution in localized areas. The major sources of urban-produced ammonia are automobile exhausts, fuel combustion, and waste incineration. Industrial sources of ammonia are refineries, fertilizer plants, and organic chemical process plants. Air quality standards for ammonia concentrations have not yet been established in the United States. The average levels of environmental concentrations are approximately 20 micrograms/cu m. Methods used to abate other pollutants with which it is associated also reduce the quantity of ammonia reaching the atmosphere. These methods include wet scrubbers, bag filters, and charcoal filters. Future emissions of ammonia are expected to be greater as a result of increases in incineration, fuel oil usage, catalytic cracking, and gasoline consumption. The principle method used for sampling atmospheric ammonia is the Nessler colorimetric method. (Author abstract modified)

18009

Darnay, Arsen, Jr.

**THROWAWAY PACKAGES—A MIXED BLESSING.** Environ. Sci. Technol., 3(4):328-333, April 1969.

Solid wastes pose many problems to the affluent society. Waste collection, waste processing, aesthetic blight from littering, soil and groundwater pollution from decomposition of organics, air pollution from waste combustion, and loss of potentially valuable raw materials are aspects of the subject which are discussed. Each of these subject areas is considered from the point of view of the basic problem, the contribution of disposable packaging to the problem, and possible approaches to solution of the problem.

18173

Kaupert, W.

**RUBBISH GASIFICATION. EXPERIENCES WITH THE RUBBISH GAS PLANT IN THE DANISH TOWN OF KOLDING.** (Muellvergasung Erfahrungen mit dem Muellgaswerk in der daenischen Stadt Kolding.) Text in German. Brennstoff-Waerme-Kraft, 20(9):433-435, Sept. 1968.

A detailed description and diagram are given of a rubbish gas plant in which rubbish is broken down mechanically to fist-size pieces, is fed from above into a 19 m-high vertical oil or gas-fired retort and is gasified at a constant temperature of 1000 C. The fuel oil consumption is 0.18 tons per ton of rubbish. The combustion gases travel through annular channels in the retort wall and through a heat exchanger in which they are cooled to 170 C and escape through a short tin flue without noticeable smoke emission. A patented 'heat muff' on top of the retort provides a heat-proof seal and removes the produced gas, mixed with steam added in the required proportion to a cooler in which the gas-steam mixture is cooled to 70 C. The heat content of the gas and the heat of condensation of the steam are used for heating. The condensate is alkaline and does not attack plant surfaces. The rubbish gas is then scrubbed in the conventional manner and fed into a gas storage tank. The ash, falling down through the bottom outlet of the retort is absolutely sterile, fine-grained and very loose and may safely be used as a fill. Other uses are under investigation. The chemical composition of rubbish gas during the year 1967 is given. Its heating value was, on the average,

3290 kcal/normal cu m. A cost estimate of the operation of a rubbish gas plant in towns of different sizes is given.

19052

Cross, Frank L., Jr.

**CAN ON-SITE INCINERATION SOLVE A WASTE DISPOSAL PROBLEM AND NOT CREATE AIR POLLUTION?** Preprint, City of Elizabeth, N. J. and Rutgers - The State Univ., New Brunswick, N. J., 10p., 1970. 5 refs. (Presented at the Air Pollution Control Meeting Elizabeth, N. J., 1970.)

The annual production of solid waste in the United States is approximately 140 million tons. The disposal of these wastes each year creates large quantities of airborne pollutants, including one million tons each of carbon monoxide, sulfur dioxide, hydrocarbons, nitrogen oxides, and particulate matter. Between the time that a community runs out of suitable land for sanitary landfill and the time when it can afford to construct a municipal or regional incinerator, on-site incineration is important in the community's waste disposal operations. Poorly designed multiple-chamber units and poorly operated units have resulted in the discharge of large quantities of smoke from single-chamber incinerators. Some state and local control agencies are passing regulations lowering the particulate emission limit to 0.1 grain/cu foot. Many units will not meet these regulations without installing some type of control device, such as a scrubber or auxiliary burner. Some factors essential to good planning have been suggested by the Incinerator Institute of America; collecting and method of charging, ample space around the incinerator, adequate air supply, adequate draft, chimney location, and current local codes and ordinances.

19547

Greeley, S. A. and Abraham Michaels

**DESIGN CRITERIA FOR MUNICIPAL INCINERATORS.** J. Air Pollution Control Assoc., 6(3):133-143, Nov. 1956. 8 refs. (Presented at the American Society of Mechanical Engineers Semiannual Meeting, Cleveland, Ohio, June 17-19, 1956.)

Two papers representing the points of view of the designer and the customer respectively include only those parts of direct interest to air pollution and its control. A description of the designer's problem is presented in terms of types of pollutants, degree of control desirable, and types of control equipment which were being tried. Cyclones, gravel filters, water, and electric precipitation were all too expensive to be risked in their present untried state; the designer should stick to the proven subsidence chamber but allow sufficient room at strategic points to permit incorporation of whichever system proves most economical in the future. From the customer's point of view, pollution control—as long as it did not increase the cost too much—was an excellent selling point to the electorate. More concern was expressed over the cost of technically competent personnel to operate automated facilities as compared to the cost of the unskilled labor required to operate conventional manual installations. Both the designer and the customer emphasized the need for equipment reliability to reduce expensive down-time and maintenance.

20153

Houry, E. and H. W. Kain

**PRINCIPLES OF DESIGN OF SMOKELESS-ODORLESS INCINERATORS FOR MAXIMUM PERFORMANCE.** American Gas Association Labs., Cleveland, Ohio, Research Bull. 93, 41p., Dec. 1962. 4 refs.

A study was conducted to reduce the quantity of particulate matter in the effluents of incinerators for domestic waste. The content of the particulate matter was measured in the flue between the primary chamber and the secondary chamber. One end of a steel pipe was inserted into the desired location while the other end extended through the outer jacket of the incinerator and was connected to the glass probe normally used in extracting the effluent sample from the stack. Production of some particulate matter in the primary chambers of present domestic incinerators may be attributed to inadequate heat distribution to the charge and/or insufficient air at the right places in the charge. The input rates of two incinerators were each increased by 10,000 Btu per hour. Particulate matter decreased as much as 87%. Uncarbonized residue remaining in the ash after incineration was reduced as much as 55%. Two domestic incinerators were equipped with power burners. The incineration rate could be greatly increased; an afterburner was not necessary for a satisfactory effluent when a more complete reaction occurred in the primary chamber. A prototype domestic gas-fire incinerator was designed and constructed. The unit operated with a particulate matter content in the flue gases of less than 0.05 grains per cubic foot.

20276

Rue, Phillip G. La

**ELECTRIC SMOKELESS AND ODORLESS INCINERATOR.** (Calcinator Corp., Bay City, Mich.) U. S. Pat. 3,496,890. 6p., Feb. 24, 1970. 4 refs. (Appl. Nov. 6, 1967, 9 claims).

A smokeless and odorless incinerator for burning garbage and other refuse is described. The refuse is placed in a primary combustion chamber where it is ignited by mounted heating elements. An afterburner is provided which reburns the smoke and gases as they flow from the primary chamber. The remaining unburned refuse in the primary chamber is dried up by a second heating device before being burned. The heating elements may be open coil resistance wires which are protected by a grid placed between them and the refuse. The second heating device is preferably placed from the bottom of the primary chamber. (Author abstract modified)

20517

Barbeito, Manuel S. and Gardner G. Gremillion

**MICROBIOLOGICAL SAFETY EVALUATION OF AN INDUSTRIAL REFUSE INCINERATOR.** Appl. Microbiol., 16(2):291-295, Feb. 1968. 6 refs

An industrial refuse incinerator was tested to determine minimal operating temperatures required to prevent release of viable microorganisms into the atmosphere. A liquid suspension of *Bacillus subtilis* var. niger spores was disseminated into the firebox as an aerosol, and dry spores mixed with animal bedding were dumped into the firebox. The minimal requirement for wet spores was 575 F for the firebox air temperature and 385 F for the firebrick refractory lining. When dry spores were used, these temperatures were 700 and 385 F, respectively. Although internal air temperatures of incinerators in continuous operation generally average 1200 to 1700 F, any one or combination of the following factors may interfere with the necessary time-temperature exposure of airborne microorganisms required for sterilization: temperature gradients caused by intermittent use, linear velocities that exceed the incinerator design and thereby reduce retention time, internal conveyors, automatic vibrating grates, charging beyond incinerator capacity, moisture content of refuse, height of stack, and type of refractory lining. (Author abstract modified)



20585

Sullivan, Ralph J.

**PRELIMINARY AIR POLLUTION SURVEY OF NICKEL AND ITS COMPOUNDS: A LITERATURE REVIEW.** Litton Systems, Inc., Silver Spring, Md., Environmental Systems Div., Contract PH 22-68-25, NAPCA Pub. APTD 69-41, 69p., Oct. 1969. 113 refs. CFSTI: PB 188070

As determined by a literature search, inhalation of nickel or its compounds can cause lung cancer, sinus cancer, other disorders of the respiratory system, or dermatitis. No information was found on the effects of emissions of nickel on commercial animals, plants, or materials. The most likely sources of nickel in urban air are metallurgical plants using nickel, engines burning fuels containing nickel additives, coal and oil combustion, nickel plating facilities, and incineration of nickel products. In 1964, the national average atmospheric concentration of nickel was 0.032 micrograms/cu m, while the national maximum concentration was 0.690 micrograms/cu m. Nickel air pollution usually occurs as particulate emissions and is controlled with the total particulates by dust handling equipment such as bag filters, precipitators, and scrubbers. The only serious abatement problem is with gaseous nickel carbonyl, which must be thermally decomposed before it can be removed as particulate. No methods for controlling nickel emissions from motor exhaust are cited in the literature. Analytical methods are available to measure nickel at the 0.006 microgram/cu m level and nickel carbonyl at the 7 microgram/cu m level.

20646

Hirayama, Naomichi, Kazuo Hishida, Sadao Konno, and Toshio Ohira

**A RESEARCH ON THE REFUSE INCINERATORS FROM THE VIEWPOINT OF SMOKE PROPERTIES.** Bull. JSME (Japan Soc. Mech. Engrs.), 11(47):902-912 1968. 4 refs.

Operating conditions, type of refuse burned, concentrations of noxious flue gas components, and the amount of dust and fly ash in flue gases were determined for 15 municipal and private incinerators in Tokyo. Integrated test results are tabulated and evaluated in terms of incinerator design criteria. Concentrations of hydrogen chloride were high where rubbish was burned, sometimes reaching 2000 ppm in emissions from department store incinerators. This amount renders furnace design almost impossible due to the metal corrosion. The concentration of HCl in the flue gas of municipal incinerators is usually less than 200 ppm, so attention should be paid to high temperature incineration and stress corrosion of metals. The total of sulfur oxides in flue gas from incinerators is less than 100 ppm. Ammonium is not produced by rubbish combustion, and that produced by garbage combustion can be substantially reduced by high-temperature incineration, as can concentrations of aldehydes. Temperature has no effect on organic acids, the total content of which is usually less than 100 ppm, but high temperatures (above 900 C) produce increased concentrations of nitrogen dioxides. The dust and fly ash content in the flue gas of continuous combustion incinerators are nearly equal to that of the batch combustion type. The ash content can be controlled by retaining the ash on the after-burning grate for a sufficient period of time. With respect to dust, dry collectors are preferable for refuse incinerators.

20737

Flowers, George H. Jr.

**APPARATUS FOR BURNING COMBUSTIBLE PRODUCTS IN EXHAUST GASES AND REMOVING FLY ASH THEREFROM.** (Waste Combustion Corp., Mechanicsville,

Va.) U. S. Pat. 3,489,109. 7p., Jan. 13, 1970. 2 refs. (Appl. July 9, 1968, 17 claims).

An incinerator is described for burning in large volume all types of rubbish or waste material, while the exhaust gases from the main combustion zone are subjected to another burning zone to insure complete combustion and to a zone for the removal of fly ash. It comprises a casing member defining a main combustion chamber and a passageway through the casing member for discharge of exhaust gases. A transition conduit communicates with the passageway for receiving exhaust gases, while there is a pressure burner for effecting a burning zone in the transition conduit. A second casing member defines a fly ash collection zone, and a baffle within the second casing member divides it into two chambers in communication with each other. The discharge opening of the transition conduit is positioned in one chamber, while a stack has an inlet opening in the other chamber. Forced air for the main combustion zone of the incinerator is supplied through holes in the casing member; the holes can be cleaned from the exterior of the incinerator. (Author abstract modified)

20759

Pelletier, Eugene

**INCINERATOR.** (Raymond Lee Organization, Inc., New York) U. S. Pat. 3,485,190. 2p., Dec. 23, 1969. 6 refs. (Appl. July 15, 1968, 5 claims).

An incinerator in which garbage and other waste is burned consists of a vertical chimney which passes upward through a multistory building; each floor has an access door through which waste can be thrown downward into the chimney. A firebox with an ash pit is at the base of the chimney and has jets of flame injected downwards. The waste is caught by dampers, disposed above the jets, which operate automatically or manually to feed the waste to the flames. Fans are situated in the chimney above the highest story to create a forced upward draft. Electrical heating coils, above the fans, completely burn the combustion products, such as flyash, drawn upward from the jets. This ensures complete burning prior to discharge to the atmosphere.

20906

Essenhig, R. H.

**INCINERATION -- A PRACTICAL AND SCIENTIFIC APPROACH.** Environ. Sci. Technol. 2(7):524-534, July 1968. 19 refs.

A progress report is given of the following projects undertaken at Pennsylvania State University concerned with the basic science and technology of incinerators: 1) study of the kinetics of typical waste materials during the combustion reaction; 2) combustion study of burning bed behavior in a small combustion pot; 3) cold-model studies of the aerodynamic patterns in an incinerator; and 4) construction and instrumentation of a small test incinerator. The types of waste are classified on a six point scale. An analysis of the types burned in an incinerator indicates that although the ratio of garbage to rubbish may vary from time to time, the basic combustible ingredients in both cases are carbohydrates, and the principle variation is in water content. For purposes of the study, the area of action in the incinerator is subdivided into two zones: zone one consists of a solid bed and 'underfire', zone two consists of gases and 'overfire'. Of the above mentioned projects, project 1) makes use of paper spheres of varying diameter made from a rapidly mixed pulp of shredded paper and water, which are burned in an airstream at differing flow velocities. Project 2) makes use of steel tubes packed with newspaper rolls or wooden pegs,



the principle of which is to form a substantially planar reaction zone at the top of the cylinder and to study this as it moves upstream against the airflow. Project 3) uses a gas tracer ( $\text{CO}_2$  or He) to determine the division of the total volume into a stirred section and a plug flow section, with the ultimate object of determining the optimum arrangement for the overfire air to be used in a test incinerator. The test incinerator of project 4) is built of super-duty firebrick, 10 feet high and 2 feet square, equipped with an optical smoke meter and a monitor gas sampling probe, both located in the stack. Plans are to analyze such gases as carbon monoxide, carbon dioxide, oxygen, and water vapor, using a variety of instruments and analyzers.

21492

Hotti, G. and R. Tanner

**HOW EUROPEAN ENGINEERS DESIGN INCINERATORS.** Am. City, 1969: 107-112, 147, June 1969.

Current European design parameters for refuse incinerators are described. Heat utilization is considered in many plants. Neighborhood nuisances can be eliminated by proper design and operation. Early systems of refuse destruction include cell furnaces, rotary kilns, and shaft furnaces. More recently, units with integrated combustion chambers proved to be superior. Maintaining a narrow temperature range, controlling the mix of the refuse, and matching the boiler size to the grate capacity all improve operating efficiency. Plant design is dependent upon firing efficiency, which is a function of all other determining factors. Due to the changing quality of refuse, redesign of incinerators is becoming necessary. Recent developmental trends are discussed.

21882

Franzke, H. H.

**REDUCTION OF EMISSIONS AT REFUSE INCINERATORS.** (Emissionsverminderung bei der Abfallverbrennung). Text in German. VDI (Ver. Deut. Ingr.) Ber., no. 149:313-317, 1970.

The heterogeneous nature of refuse material makes any reduction of emissions difficult. Incinerators primarily emit dust (1 to 20 g/cu m), sulfur dioxide and sulfur trioxide (500 to 2500 mg/cu m), hydrogen chloride (150 to 1500 mg/cu m), and odors. The Federal government has imposed emission limits on incinerators, namely 150 mg/cu m of dust for plants with a circulation of 1.5 tons/h, and 200 mg/cu m of dust and a carbon dioxide-content of 7% for plants with a capacity below 1.5 tons/h. Technical measures for the reduction of emissions are discussed in the VDI (Association of German Engineers) guidelines 2114 and 2301. High stacks help to reduce high emission concentrations. For flue gas cleaning, the gases must first be cooled to temperatures between 150 and 250 C, while the liberated heat can be used for power generation. If no heat utilization is contemplated, water or fresh air must be used for cooling the gases. Electrostatic precipitators are primarily used for dust separation in large incinerators. In storage bunkers an underpressure must be maintained to avoid spread of disagreeable odors.

21952

Kaiser, Elmer R.

**EVALUATION OF THE MELT-ZIT HIGH-TEMPERATURE INCINERATOR. (OPERATION TEST REPORT).** Public Health Service, Cincinnati, Ohio Bureau of Solid Waste Management, City of Brockton Grant DOI-U1-00076, 113p., Aug. 1968. 13 refs. CFSTI: PB 187309

The performance of a high-temperature incinerator was tested in terms of its potential for practical application. The incinerator is unique in that it is basically a vertical, cylindrical shaft furnace with a refractory lining. The non-combustible fractions of refuse are melted in a bed of high-temperature coke, and drained from the furnace as molten slag and iron. Organic matter in the residue is thereby automatically prevented and complete sterility is achieved. The residue has a high density. In the state of development and method of operation at the time of testing, the pilot incinerator did not perform satisfactorily or reliably. The process has sufficient promise to warrant further design and development. The technical advantages of the incinerator are a residue free of putrescible matter, maximum density of landfill, and the elimination of ground water or stream pollution from deposit of incinerator residue. The emission control system was not operative during the test in order to permit stack gas sampling. Gaseous emissions were comparable to those of well designed conventional incinerators. Particulate emission averaged approximately 13 lbs/1000 lb gas. No odor was detectable.

21991

Stahl, Quade R.

**PRELIMINARY AIR POLLUTION SURVEY OF ALDEHYDES. A LITERATURE REVIEW.** Litton Systems, Inc., Silver Spring, Md., Environmental Systems Div., NAPCA Contract PH 22-68-25, Pub. APTD 69-24, 134p., Oct. 1969. 221 refs. CFSTI: PB 188081

The effects, sources, abatement, and methods of analysis of aldehydes are reviewed, as ambient air measurements indicate that in 1967 the average concentrations for several cities ranged from 3 to 79 micrograms/cu m. Vehicle exhaust appears to be the major emission source, but significant amounts may be produced from incineration of wastes and burning of fuels. Local sources of aldehydes may include manufacturing of chemicals and other industrial processes that result in the pyrolysis of organic compounds in air or oxygen. Atmospheric aldehydes can also result from photochemical reactions between reactive hydrocarbons and nitrogen oxides, and moreover, they can react to produce other products, including ozone, peroxides, and peroxyacetyl nitrate compounds. Low concentrations principally affect humans and animals by irritation of the mucous membranes of the eyes, upper respiratory tract, and skin; animal studies indicate that high concentrations can injure the lungs and other organs of the body. Although combustion control methods, such as catalytic afterburners, generally decrease the amount of hydrocarbon emissions, they may actually produce greater amounts of aldehydes. Common sampling methods employ bubblers or impingers containing a reactive reagent, while infrared spectroscopy, and many colorimetric methods are applicable to formaldehyde, acrolein, and aldehydes. (Author abstract modified)

22130

Murakami, Masakata, Takashi Kawashima, and Kamichiro Kamitsu

**ISOGO INCINERATION PLANT IN YOKOHAMA.** (Yokohamashi seisokyoko isogo kojo ni tsuite). Text in Japanese. Kukichowa Eisei Kogaku (J. Japan Soc. Heating, Air-conditioning, Sanitary Engrs.), 44(2):131-138, 1970.

Equipment and facilities recently installed at Isogo Waste Treatment Plant are described. The site covers 13,141 sq m including a 7330 sq m building site. The plant is comprised on a main building, containing three basements and five floors, a waste dumping building, a furnace wing off the main building,

and adjoining structures. The nominal incinerating capacity is 300 t/day with a peak load capacity of 450 t/day to handle seasonal increases. To eliminate the conventional image of waste disposal facilities and to emphasize the modern sanitary working environment, many advanced concepts were incorporated. The use of multi-cyclone and electric dust collectors keeps soot and smoke emissions below 0.1 g/N cu m. Chimneys 85 m tall with exhaust velocities greater than 20 m/s effectively disperse all smoke. The pit chamber is air tight to prevent the discharge of noxious odors. Waste water is treated to meet the requirements of the Water Quality Standard. At night, noise is suppressed to less than 50 phn. The furnace is operated from a central control room which includes a closed TV monitor system to permit overall supervision of the site activities. In the furnace room, air is recirculated 20 times per hour and 10-15 times per hour in other operating and staff areas. Offices, equipment rooms, control rooms, exhibit rooms, and some others are heated and air-conditioned. Surplus steam from waste heat boilers is used in the sludge digestion tanks. Surplus gas, mostly methane, is used as a subsidiary fuel. To prevent flooding, the first floor was built 5 m above the average tide level of Tokyo Bay.

22540

**AIR POLLUTION AND AIR CLEANER.** (Taiki o sen to kuki seijoka sochi). Text in Japanese. Kukichowa to Reito (Air Conditioning Refrig.), 10(2):52-55, Jan. 15, 1970. 3 refs.

The filter was reviewed regarding its application to air pollution countermeasures: elimination of pollutants and injurious gases. Suspended particles in air are less than 10 microns in size and their amount increases in the order of rural district, city and industrial area respectively. The density of particles in atmosphere at an emission source was as much as ten times the average quantity. Harmful gases occur due to combustion of fuel and the treatment process of chemical materials. Internal combustion engine, melting furnace for metals and garbage incinerators are considered as the source of combustion process type pollutants. Treatment process type of pollution sources are petrochemical plants and the sulfuric acid industry. Sulfur dioxide is emitted because of sulfur in fuels; carbon monoxide and nitrogen oxides are found mainly in auto-exhaust gas. Air cleaning filters must be selected according to various objectives such as air-cleaning for people, protection of apparatus, or quality control. Dust collection rate of an air filter is measured by different methods such as gravimetry (more than 1 micron), colorimetry (less than 1 micron), and DOP method (less than 0.3 micron). The points of selecting air filter are required purity, air flow capacity and working period. High purity is required for clean rooms, precision machine rooms and for eliminating injurious particles. Filters for these purposes need a high gathering rate. The HEPA filter is usually used. In its application, consideration must be given to the structure of filter chamber, air leak of installed surface of apparatus, structure of duct and the location of the fan. A pre-filter is desirable to lengthen the life of the HEPA filter. Filters with a large flow capacity should be chosen with the eye on low operation cost and a continuous use of 8-12 months. Auto-winding type of electrostatic self-washing type of filter is preferred for long period use. Adsorption by active carbon is used for the elimination of injurious gas. The adsorption efficiency for sulfur dioxide and hydrogen sulfide is 80-90% for 13 mm thickness of active carbon. Effective use of active carbon filter requires the use of a prefilter.

22642

Niessen, Walter R. and Adel F. Sarofim

**INCINERATOR EMISSION CONTROL.** Ind. Water Eng., 7(8):26-31, Aug. 1970.

Methods of controlling both particulate and gaseous incinerator emissions are reviewed. Particulate emissions are best controlled by improvement of the combustion process itself, especially elimination of underfire air. Entrainment of mineral particulate (the incombustible fraction of fly ash), however, will not be completely eliminated by this procedure since the buoyancy of the combustion gases will induce an air flow producing a minimum particulate emission. Entrainment of particulate by buoyancy-driven flows will, therefore, increase with furnace size and flame temperature. Of the three types of combustible particulates, char is entrained at low velocities in amounts depending on the make-up and degree of agitation in the refuse bed. Soot formation may be prevented by proper design and placement of overfire air or stream jets. Smoke produced by unreacted hydrocarbons can be eliminated by afterburning or the adjustment of air flow to a furnace to provide better overhead mixing. Control of gaseous combustible pollutants, hydrocarbons and carbon monoxide, is contingent on proper mixing between partially burned products of pyrolysis and air and fuel in an afterburner. Because of projected increases in hydrogen chloride emissions, consideration should be given to countercurrent flow, multiple tray plate-type scrubbers for the recovery of noncombustible gaseous pollutants.

22860

Chansky, Steven H., Anne N. Dimitriou, Edwin L. Field, Charles R. LaMantia, and Robert E. Zinn

**SYSTEMS STUDY OF AIR POLLUTION FROM MUNICIPAL INCINERATION, VOLUME II. (APPENDICES).** Little (Arthur D.) Inc., Cambridge, Mass., NAPCA Contract CPA-22-69-23, 312p., March 1970. 39 refs. CFSTI: PB 192379

Volume II of a three volume report presents, largely in tabular and graphic format, data pertinent to a systems study of air pollution from municipal incineration. The scope, conclusions, and recommendations are contained in Volume I; Volume III consists of a comprehensive bibliography. The cost of reducing solid waste to a workable size; processes, physics, and costs of reducing flue gas temperatures for compatibility with air pollution control equipment; the stoichiometry of refuse incineration; operating experience on European electrostatic precipitators; by-product recovery, including paper, metal, and heat; composition of refuse; and the projected composition and quantities through the year 2000 are presented. A detailed description is provided of the incineration process from collection to disposition of residue, with consideration being given to equipment options; air pollution via odors, smoke, particulates, and gases; process control; waste water disposal; site requirements; buildings; and utilities. A specimen questionnaire is included that was used to obtain data from the industry on incinerator inventories, capacities, current design trends, and operating practices. Data obtained through the use of this questionnaire are presented and analyzed. The causes and extent of air pollution problems associated with municipal incineration are defined, and a data bank of incinerator emission data is presented. Causes and cures for incinerator deficiencies are discussed.



22862

Chansky, Steven H., Anne N. Dimitriou, Edwin L. Field, Charles R. LaMantia, and Robert E. Zinn

**SYSTEMS STUDY OF AIR POLLUTION FROM MUNICIPAL INCINERATION. VOLUME I.** Little (Arthur D.) Inc., Cambridge, Mass., NAPCA Contract CPA-22-69-23, 599p., March 1970. 75 refs. CFSTI: PB 192378

A number of actions are described, both in terms of equipment modifications and operating practices, that can be taken to reduce air pollution emissions, while moving to the objective of improved techniques for the disposal of solid waste by incineration. The following nine recommendations are made: 1) Cooperation, cost sharing, joint funding, and other collective means should be exploited through all levels of the public and private sectors to encourage and hasten the development and implementation of low-pollution incinerator systems. 2) Because a mere 5 to 8% cost factor differentiates incinerator systems with token APC devices compared from those with a first-class APC system additional funding to meet the latter objective should be seriously considered by agencies now contemplating construction of new facilities. 3) Since the particulate control efficiency (52% average) of the APC systems of plants built in the 1963-1968 period will not be acceptable in the future, the APC performance targets for new plants must be raised to reverse current air pollution trends. A control level of 90% would essentially curtail the rapid increase in total emission in spite of the anticipated four-fold increase in the quantity of refuse incinerated. If the effluent quality of existing plants is improved simultaneously, the total annual particulate emission rate could approach a minimum value by the year 2000. 4) Federal and state sponsorship of programs to demonstrate the performance advantages and possibilities of air pollution control based on new concepts and techniques should be encouraged. 5) Better mixing techniques must be adopted and incorporated in incinerator systems to reduce or eliminate combustible pollutant emission. 6) Undergrate air flow should be reduced to the lowest levels possible and controlled to lessen particulate liftoff consistent with burning rate and grate protection considerations. 7) In view of the proven efficiency of filter bags as APC devices, more advanced experimentation and testing should be considered. 8) Advanced technology concepts should be given due consideration. Of the three described; slagging, fluidized bed, and pyrolysis, the latter deserves prompt attention because it can effect substantial reductions in combustible emissions and flue gas volume. 9) In view of projected increases in hydrogen chloride emissions from incinerators, consideration should be given by both private and public sectors to seek methods to minimize increases in the use of halogenated polymeric materials.

22873

Davis, (W. E.) and Associates, Leawood, Kans.

**NATIONAL INVENTORY OF SOURCES AND EMISSIONS. CADMIUM, NICKEL AND ASBESTOS. 1968. SECTION III. ASBESTOS.** NAPCA Contract CPA 22-69-131, NAPCA-APTD-70, 46p., Feb. 1970. 2 refs. CFSTI: PB 192252

The flow of asbestos in the U. S. is traced and charted for 1968 in mining and processing, imports and exports, and reprocessing (e.g., friction material, asbestos cement products, floor tile, textiles, and asbestos paper). Apparent consumption was 817,363 tons with domestic production only 120,690 tons; most imports were from Canada. There was no recovery from scrap. Emissions, emission factors, and brief process descriptions are given for mining and other basic processing, reprocessing, consumptive uses (road surfacing, construction, brake linings, steel fireproofing, motor vehicle use, and insu-

lating cement), and incineration and other disposal. Emissions to the atmosphere during the year were 6579 tons. About 85% of the emissions were due to mining and milling operations. Estimates of emissions are based for the greatest part on observations made during field trips, and on the limited information provided by mining, milling, and reprocessing companies. Information was not available regarding the magnitude of the emissions or the particulate size. There were no emission records at any of the locations visited. An appendix gives the names and locations of industrial firms involved in asbestos processing and use.

23025

**MONTREAL INCINERATOR TO BE CLEAN STEAMER.** Eng. News-Record, 183(6):62-63, Aug. 7, 1969.

The design features of a new 1200-ton per day incinerator now under construction in Montreal are described. The incinerator has a 2400-ton capacity collection pit to hold wastes dumped by collection trucks. The wastes will go through four completely sealed 300-tpd furnace units designed to keep the temperature range between 1500 and 1830 F to produce a 99.7% burnout rate. Furnace gases will heat water in a complex series of coils, turning it into steam which the city will sell, with the expectation of reducing solid waste disposal costs by half. To control emission of atmospheric pollutants, the flue gases will pass through an electrostatic precipitator. Ash emission level will be under 0.17 lb per 1000 lb of gas, well below official city limits. The manufacturer has given the city a written guarantee of the installation's maximum downtime.

23313

Alkire, H. L.

**AIR POLLUTION IN CAROLINE COUNTY MARYLAND.** Maryland State Department of Health, Baltimore, Div. of Air Quality Control and Caroline County Dept. of Health, Denton, Md., 19p., Jan. 1970. 15 refs.

The present survey emanated from the need of the Division of Air Quality Control of the Maryland State Department of Health to have a county by county statement, based on available information, on the status of air contamination in the various areas. The survey was made in accordance with authority granted under the Maryland Air Quality Control Act (Article 43, Annotated Code of Maryland, 1957 Edition and Supplement). Regulations have been adopted by the county governing the control and prohibition of open fires, the control and prohibition of visible emissions, and the control and prohibition of particulate emissions from fuel combustion. Amendments to these regulations which became effective on January 29, 1969 govern the sulfur content of all heating oils and of oil used in very large installations after July 1, 1970; prohibit removing air pollution control devices from motor vehicles as well as requiring that the devices be kept in operating condition; provide for the control of the discharge of gases, vapors or odors; and, in addition, are concerned with control of visible and particulate emissions from industrial and incineration operations. Plants at Denton and Ridgely fortunately have been located so that those communities are upwind of the prevailing west and northwest winds. Two poultry processing plants create the types of odors usually associated therewith but they are rurally located. There are no plants for the rendering of inedible portions of chickens in the county. Five dumps are used for the disposition of about 8500 tons of refuse annually. The burning of material is on an irregular schedule and is somewhat controlled. However, material is not covered frequently and the dumps are odorous. Investigations



are under way with the aim of substituting sanitary landfills for the dumps. The disposal of home-generated trash and leaves in smaller communities and by burning is a general practice. The processing of clams near Ridgely produces some odors which escape into the town and may lead to objectionable conditions. However, some residents of the area reported that they were not of an objectionable nature. Smoke has been emanating periodically from the stack of milk plant in Greensboro, but this is resulting from improper operation of new equipment which was installed to correct previously unsatisfactory smoke emissions.

23314

Alkire, H. L.

**AIR POLLUTION IN TALBOT COUNTY MARYLAND.** Maryland State Department of Health, Baltimore, Div. of Air Quality Control and Talbot County Dept. of Health, Easton, Md., 19p., Jan. 1970. 14 refs.

The present survey emanated from the need of the Division of Air Quality Control of the Maryland State Department of Health to have a county by county statement, based on available information, on the status of air contamination in the various areas. The survey was made in accordance with authority for the Secretary of Health and Mental Hygiene to adopt regulations governing the control of air pollution in the State. Regulations applicable in Talbot County have been adopted governing the control and prohibition of open fires, the control and prohibition of visible emissions, and the control and prohibition of particulate emissions from fuel combustion. Amendments to these regulations which became effective on January 29, 1969 govern the sulfur content of all heating oils and of coal used in very large installations after July 1, 1970; prohibit removing air pollution control devices from motor vehicles as well as requiring that the devices be kept in operating conditions; provide for the control of the discharge of gases, vapors or odors; and, in addition, are concerned with control of visible and particulate emissions from industrial and incineration operations. Most sources of air pollution in Talbot County, although relatively small and few in number, are clustered in the Easton area. Pollution generally is associated with the processing of vegetables, the shelling and drying of corn which create 'beeswing' chaff, and the processing of seafood. Other than in the Easton area, these are widely scattered and objectionable levels of pollution are localized. Almost all refuse material is disposed of in landfills. However, burning sometimes occurs at the Tilghman-Sherwood dump and occasionally at the St. Michaels dump.

23584

**A NEW APPROACH TO INDUSTRIAL AIR POLLUTION CONTROL.** Heating Ventilating Engr. J. Air Conditioning (London), 44(517):80-85, Aug. 1970.

The exploration and development of technology and hardware to optimize the standards and pave the way for the most economical and efficient incinerator design possible are presented. Included in the laboratory research facility was a reaction chamber with probe connections for temperature and velocity measurements as well as compositions analysis for oxidation rates at various points. Extensive studies were made to furnish basic reaction kinetics of many hydrocarbon air contaminant materials, and mention is made to toluene as the most difficult of the samples shown to oxidize. To achieve effective mixing capabilities with extremely low air stream pressure loss, an incinerator burner which produces a 'ring of flame' was designed, and a full scale incinerator facility to accommodate this new burner was constructed. A series of

tracer concentration measurements were performed to evaluate mixing efficiency of the burner, but the proof of performance was revealed in actual incineration tests using toluene. A complete mock-up of the jet incinerator was next constructed in the laboratory for aerodynamic studies previous to construction of practical equipment for commercial marketing. The purpose of the jet incinerator is not only to incinerate hydrocarbon process effluent, but also to be capable of developing a suction to entrain the fumes without requiring external exhausters or fans. A surface injection incinerator was designed as a very rugged, heavy duty type of combustion system for high temperature operation. This unit is equipped with a pair of burners firing tangentially at the combustion end to form a circular 'hot track' of burner gases in a restricted area. An injection nozzle is located axially at this point, where the process effluent is introduced under pressure and distributed directly into the burner combustion track. Typical problems of air pollution abatement to which these direct flame type fume incinerators find application are indicated.

23815

Kinney, Leslie Junior

**METHOD AND APPARATUS FOR COOLING AND PURIFYING GASEOUS PRODUCTS OF COMBUSTION.** (Chillum Sheet Metal, Inc., Bladensburg, Md.) U. S. Pat. 3,522,000. 4p., July 28, 1970. 6 refs. (Appl. Sept. 6, 1967, 10 claims).

The invention provides a method and apparatus for removing fly ash, smoke, and sulfur dioxide from incinerator gases; it includes treating the gases with ammonium hydroxide. In a known process for scrubbing gases, an ammonium hydroxide spray is used in the initial cleaning stage. This procedure is of little use under conditions of incineration, where the addition of ammonium hydroxide to the high-temperature gases could cause intermediates formed by reactions between different gas constituents to react violently. Moreover, sulfur dioxide at this stage would combine with ammonium hydroxide to produce an ammonia sulfite salt that would immediately revert to the gaseous stage. The invention is based on adding ammonium hydroxide subsequent to a series of cooling and washing steps. Smoke and gases are first led to a heat exchanger comprising an air-cooled heat sink, then passed to a chamber comprising sprays, screens, and baffles. Here suspended particles are first removed from the gases and the temperature of water-soluble gases reduced to about 70 F. When this temperature is reached, the remaining gases are sprayed with ammonium hydroxide by means of which the gases form water-soluble compounds. The latter are moved by a terminal water spray.

24013

Sacramento Regional Area Planning Commission, Calif.

**GENERAL INVENTORY OF AIR POLLUTION SOURCES AND EMISSIONS.** In: The Air Pollution Threat. Technical Paper -1, 13p., Oct. 1969. 8 refs. CFSTI: PB 191382

The results of an inventory of pollution sources and emissions within the Sacramento region are tabulated for three categories: transportation (gasoline and diesel vehicles, railroads, and aircraft); agricultural waste burning; and stationary sources (agricultural product processing, petroleum handling to service vehicles, solvent use, solid waste incineration, metal processing, mineral processing, chemical manufacturing, and combustion of fuels, mainly natural gas). The data were obtained by applying emission factors to information on types and amounts of materials processed, collected by several area agencies, and from existing surveys and reports. The inventory covers emissions of organic gases, carbon monoxide, nitrogen oxides, sulfur dioxide, and particulate matter.

24241

**ARE THESE INCINERATORS THE ANSWER TO PLASTICS WASTE?** *Mod. Plastics*, 47(10):102-103, Oct. 1970.

Three Japanese incinerator manufacturers have developed models designed specifically for plastics waste and which, reportedly, do not emit any polluting gases. One model has two main burning chambers and a preliminary heating chamber. Each of the chambers has a fan that forces compressed air into the burning area, the compressed air allowing the furnace to be fired without a starter. Main chamber temperatures vary from 820 to 880 C. While a variety of plastics can be burned, only one type of resin can be destroyed in a single load in this model. Moreover, the model cannot handle polyvinyl chloride without producing air pollution. In the second model, plastics to be burned are first pulverized in a crusher, then baked in a special rotary kiln at 300 C. Hydrogen chloride produced from this process is reacted with ammonia and collected in the form of ammonium chloride. Other gases and carbon black are automatically passed to a second furnace chamber and burned at 1000 C. The load is subsequently passed through a heat exchanger and a dust collector. The life of this furnace is estimated at 15 years in contrast to the seven years claimed for the other furnaces. The third model, which has four chambers, can burn PVC without significant air pollution. It, too, handles only one type of plastic at a time. Chamber temperatures are 1100 C.

24421

Bohne, Helmut

**HYDROGEN CHLORIDE EMISSIONS FROM HOSPITAL INCINERATORS.** (Chlorwasserstoff-Emissionen durch Verbrennungsanlagen von Krankenhausern). Text in German. Staub, Reinhaltung Luft, 30(8):337-339, Aug. 1970. 3 refs.

Severe damage to plants of two nurseries by hydrogen chloride emissions from hospital incinerators initiated a study of such emissions. The dust from these incinerators contained a far higher chlorine content than was found in other dust samples. The chlorine content of dust from flues and cyclones was higher than that of the furnace ashes. Flue gas HCl determinations registered from 25.7 to 895 mg HCl/N cu m with the highest pollution level measured 10 minutes after the last charging of the furnace. Thus, the sudden combustion of the chlorine-rich components of refuse at temperatures from 800 to 1000 C is responsible for the HCl formation. It is irrelevant for HCl emission whether smaller charges are added more frequently or larger charges less frequently. The median emission level of measurements made at two minute intervals was in one installation, 136 mg HCl/N cu m. In another instance, single measurements yielded emissions of up to 1382 HCl/N cu m. Twenty to thirty m high stacks are clearly not high enough prevent damage to plants from HCl emissions.

24582

McCutchen, Gary D.

**A COMPARISON OF NAPCA AND IIA SOURCE SAMPLING METHODS.** Preprint, American Society of Mechanical Engineers, New York, 12p., 1970. 2 refs. (Presented at the September 30, 1960 Meeting of the American Society of Mechanical Engineers, Incinerator Division, New York, N. Y.)

Among the most widely used incinerator sampling techniques are those developed by the Incinerator Institute of America and the National Air Pollution Control Administration. Tests involving simultaneous measurements of particulate emissions from a multiple-chamber retort incinerator by the IIA-6 train and the NAPCA train indicate that tests results vary appreciably. Sampling was conducted at the inlet and outlet of

the scrubber downstream of the fan, and the ratio of NAPCA to IIA results before and after the scrubber was plotted on log-probability paper. The difference between the inlet and outlet lines indicates that inlet and outlet ratios vary; and since the main difference between inlet and outlet ratios was the particulate loading of the flue gas, there is a possibility of a correlation between the ratios and particulate loading.

24767

Rose, Andrew H., Jr. and Hoyt R. Crabaugh

**RESEARCH FINDINGS IN STANDARDS OF INCINERATOR DESIGN.** In: *Problems and Control of Air Pollution*. F. S. Mallette (ed.), New York, Reinhold, 1955, Chapt. 10, p. 95-106. 6 refs.

Two design parameters are developed for multiple-chamber incinerators; these parameters are emphasized because studies to date indicate that inferior performance and discharge characteristics occur when the design of the ignition chamber or primary combustion stage is inadequate. Data are given for combustion air distribution showing that where overfire air is the predominant means of supplying the required combustion air, the total discharge of contaminants to the atmosphere is decreased; the degree of reduction depends on the incinerator design. The type of ignition mechanism is independent of equipment size. Recent results support the hypothesis that discharge of 0.5 - micron particles results from chemical reaction and volatilization of metallic compounds present in the fuel bed with a condensation and chemical reaction occurring in the oxidizing gas stream above the fuel bed. Three relationships are considered with respect to ignition chamber proportions: grate loading, arch height, and length to width ratio of the fuel bed. It is understood that lower arch height reduces contaminant discharge, but further data for definitive evaluation of all three factors are required.

25056

Ishii, Kazuo, Matsuoki Okuda, Mutsuo Koizumi, Tadahiro Machiyama, Katsuya Nagata, and Noboru Sugimoto

**HIGH PERFORMANCE INCINERATION OF SEWAGE SLUDGE. PART II. INCINERATOR WITH SLAG-TAP FURNACE.** (Konoritsu no gesui odei shokyaku sochi ni kansuru kenkyu. ni. Yukaishiki odei shokyaku sochi). Text in Japanese. Nenryo Kyokaishi (J. Fuel Soc. Japan, Tokyo), 49(521):674-682, Sept. 20, 1970. 7 refs.

A new type of incinerator with a slag-tap furnace for dewatered sludge consists of an atomizing feeder of sludge, a heat exchanger, an air preheater and a cyclone dust collector. The air-jet type sludge atomizer, referred to in Part I of the article, and a heavy fuel oil burner are placed at the top of the furnace. Refractory materials which are packed in the furnace are suspended by five water-cooled tubes with refractory coating and are heated by firing fuel oil. Dewatered sludge is fed in particulate form and burned immediately when it gets in contact with the high temperature, high speed combustion gas of the fuel oil. Ash in the sludge is melted into slag and flows down into a slag pit through the bank of refractory materials. The incinerator system has the following merits: dustless flue gas is emitted from the furnace, because the ash in sludge is melted into slag at the bank of refractory materials; flue gas is odorless because of high temperature combustion; and the incineration plant can be compact in size and still possesses high performance. This type of incinerator is used more effectively for dewatered raw sludge than for dehydrated sludge, just as in the case of the AST method, since dewatered sludge contains more water and is more convenient for transportation and dispersion. Further, since dewatered raw sludge has not



gone through digestion, it contains more organic matter and emits higher heat. The system is applicable to not only sewage sludge, but also for burning sludge in factory effluents which hardly contains any flammable matter, or the sludge which is especially high in water content. The system is only a small test incinerator, with only 100 kg/h capacity. After more experience is gained in taking out melted ash and in testing durability of the incinerator, more problems will be solved.

25220

Niessen, Walter R. and Adel F. Sarofim

**THE EMISSION AND CONTROL OF AIR POLLUTANTS FROM THE INCINERATION OF MUNICIPAL SOLID WASTE.** Preprint, International Union of Air Pollution Prevention Associations, 65p., 1970. 42 refs. (Presented at the International Clean Air Congress, 2nd, Washington, D. C., Dec. 6-11, 1970, Paper EN-5C.)

Information is presented which is directed to incinerator designers and operators and to air pollution control officials having interest in the variables affecting the emission rates of pollutants from municipal (and industrial) solid waste incinerators. The conclusions reached regarding typical emission rates and the causes of emissions are based on analysis of experimental data from over 100 incinerators in the U. S. and Europe. It is shown that refuse composition, system design, and operating techniques can affect the emission rate and thus emissions can, in part, be reduced by means other than air pollution control devices. Particulate emission rate is increased by increases in: refuse fine ash content, underfire air rate, and furnace size, and appears related to grate type, refuse volatile matter, and mixing effectiveness in the combustion chambers. Review of combustion rate correlation suggests inadequate mixing as the reason for the survival of combustible pollutant species as the average flue gas characteristics (well-mixed) should foster their destruction. Nitrogen oxides emissions are seen related to furnace heat release rate. Sulfur dioxide and hydrogen chloride emissions are related to refuse composition. Typical air pollution control devices are seen able to remove incinerator particulate but with difficulty owing to the small particle size of much of the fly ash in comparison to coal or oil-fired boilers. The cost to use effective control systems is shown as about twice the cost of the low-energy scrubbers often used in the U. S. The total operating cost increment (including debt retirement) for systems approaching 95% collection efficiency, however, is only about 5% over the costs for the much less efficient systems (35-50% collection). Author abstract

25549

Kettner, H. and R. Langmann

**OBJECTIONABLE SOOT EMISSIONS.** (Zur Frage des Auftretens von Belaestigungen durch Russ). Text in German. Oeffentl. Gesundheitswesen (Stuttgart), 32(7):346-348, July 1970. 3 refs.

Soot emission sources include household furnaces, internal combustion engines, small industries, thermal power plants, coke ovens, airplanes, nonferrous metal smelting plants, railroads, incinerators, carbon black works, incinerators of agricultural residues, forest fires, fires from burning old tires, from old oil and from tar. Soot is not harmful when pure but soot from sulfur containing heavy oil (smut) contains considerable quantities of sulfuric acid. Soot is also a carrier of cancerogeni 3,4-benzpyrene in smogs and is a contributory factor in the formation of smog. Soot is objectionable as a deposit. An objective soot emission test filters a dust precipitate deposited in a month through a glass wool filter

and measures the blackness of the stain by an optical electric reflectometer. The thus obtained soot pollution index is a dimensionless number which calculated for 1 day lies between 0.2 and 3. This method permits the setting of norms of maximally permissible soot emissions which has hitherto not been done.

25862

Truss, Heinz-Walter

**EMISSION OF HYDROGEN CHLORIDE DURING REFUSE INCINERATION.** (Die Emission von Chlorwasserstoff bei der Verbrennung von Hausmuell). Text in German. Energie (Munich), 22(10):300-305, Oct. 1970. 5 refs.

Since the combustion of pure polyvinylchloride produces about 58% by weight of hydrogen chloride in the resulting combustion gas, and since PVC occurs increasingly in refuse, its content is a factor determining to a large extent the hydrogen chloride content resulting from refuse incineration. Fearing a rise in HCl emission from refuse incineration as a result of the introduction of disposable PVC bottles, a study of the HCl content in waste gas from the incineration of homogenized refuse and the chlorine content in cinders and in fly ash of refuse of a known PVC content was commissioned by the city of Hamburg. Gases from the combustion of 4500 kg refuse of a median PVC content of 0.44% and of a median calorific value of 2000 kcal per kg refuse were analyzed. Results revealed that most of the chlorine content in refuse escapes in the waste gas; only small quantities remain in cinders and in fly ash. The chlorine content in the fly ash rises with rising PVC content in refuse linearly; for cinders, just a rise with rising PVC content could be found. A waste gas flow of 35000 N cu m/hr contained 5000 mg HCl/N cu m. The maximal permissible ground concentration of 0.1 mg/ cu m was reached only by a tenfold emission corresponding to a 6.5 to 7% by weight content of PVC. This relatively high maximal permissible concentration level is due to incinerators having high stacks. Hydrogen chloride emission levels in incinerator waste gases can be reduced by 80-90% by the use of scrubbers which require that their waste water be neutralized. The cost of this purification is high and comes to approximately \$2.25 per ton of refuse for an installation with neutralization and dust removal.

26204

Faatz, Albert C.

**A CENTRALIZED INCINERATION FACILITY FOR INDUSTRIAL WASTE DISPOSAL.** Water Sewage Works, 116(R.N.):R-197-R199, R201-R202, Nov. 28, 1969. 1 ref. (Presented at the National Pollution Control Conference and Exposition, 2nd Annual, Houston, Tex., April 22-24, 1969.)

An incineration facility to be constructed on the Houston Ship Channel will have a capacity of 15,000 tons of waste per month, representing about 20-25% of the quantity of waste from the area chemical plants available for treatment. The facility's location will make it available by barge, truck, or rail car. Incoming receipts will be divided into three categories. Those that can be atomized or otherwise converted into small particles will be treated in a 'liquid' furnace that is basically an adiabatic combustion chamber. Materials having large contents of ash or inorganic noncondensibles will be incinerated in a rotary hearth. Materials that are relatively large in size and those that burn slowly will be incinerated in a rotary kiln. Combustion gases from the three incinerators will be combined, then taken to a secondary combustion furnace where oxidation of potential or actual gas pollutants will be completed. This chamber is designed to combine the three essential elements of

combustion-time, temperature, and turbulence-in such a manner as to complete burning of soot, hydrocarbon vapors, of sulfur-containing materials, and of odor or smog-producing compounds. Before passing to the stack, the combustion gases will be treated in a wet scrubber for the simultaneous removal

of particulates, sulfur oxides, and hydrogen chloride. As pressures to conform to pollution control regulations become more severe, a centralized facility such as that described may be the only alternative to plant shut-down.



## B. CONTROL METHODS

00107

S. S. Griswold

**CONTROL OF STATIONARY SOURCES (TECHNICAL PROGRESS REPT. VOLUME 1).** Los Angeles County Air Pollution Control District, Calif. Apr. 1960. 191 pp.

As a result of the intensive source control measures administered in Los Angeles County, Virtually all industrial operations have been brought within the scope of the air pollution control program. From the melting of metal to the painting of manufactured goods, specific industrial processes and equipment have been subject to air pollution control measures. This volume provides individual discussion of control techniques applied to the most significant stationary sources of air contamination. Certain source emission problems, such as those traceable to the operation of railroad locomotives and ships, are not discussed in this volume in view of the current unimportance of the source. The material reported in this volume generally contains only those developments occurring subsequent to the publication of the Second Technical and Administrative Report on Air Pollution Control in Los Angeles County, 1950-51. (Author)

00183

L. P. Flood

**AIR POLLUTION FROM INCINERATORS - CAUSES AND CURES.** Civil Eng. 44-8, Dec. 1965.

Of all the things that civil engineers build, probably large central incinerators cause the greatest amount of air pollution. Most large cities must resort to incineration to reduce the weight and volume of their wastes to manageable proportions, and to change the character of these wastes so that disposal does not cause secondary problems of water pollution, vermin infestation or odor emission. To attain this goal, incineration must be so complete that the organic matter left in the residue is less than 5 percent of the residue by weight. If an incinerator is to successfully burn the rated capacity of solid waste to a non-putrescible residue, without creating a nuisance, certain design principles should be followed. It is essential to recognize that: (1) the three T's of combustion must be provided: temperature for complete burnout, turbulence for thorough mixing of the combustibles with the air, and time so that combustion can be completed in the furnace. (2) Air must be used efficiently. (3) The fuel bed should be gently agitated to promote complete burnout without increasing fly-ash emission. (4) The most effective dust cleaning equipment should be utilized so that dust emission will be minimized. (5) A high stack is an effective mean of decreasing the amount of pollution at ground level. (6) A continuous type of incinerator is likely to cause less pollution than a batch type. (7) A water-cooled furnace permits higher burning temperatures and avoids many of the costs and troubles experienced with a refractory-lined furnace. (8) Three-shift operation avoids the pollution and deterioration of plants concomitant with repeated starts and stops. (9) Not all the air pollution from an incinerator comes from the stack. Means for minimizing pollution from all sources must be provided.

00246

**TROUBLE FREE WASTE INCINERATION.** Southern Eng., 84(6):54-55, June 1966.

A three-burner natural gas incinerator having a capacity of 3,000 pounds per hour is described. The patented 3-chamber, semi-parabolic design of the incinerator affords maximum reflection and heat concentration for complete combustion. Centrifugal force traps soot and fly ash. Partially-combusted gases and non-combustible particles from the first chamber are drawn into a second chamber, where a continuous supply of fresh air is introduced to complete combustion of the gases and burn off smoke and odors. Combusted gases and particles enter a third chamber, in which the after-burning process is continued and particles are removed before gases enter the stack. Five hundred pounds of refuse are reduced to a shovel full of ashes.

00288

H. C. Johnson, J. D. Coons, and D. M. Keagy

**CAN MUNICIPAL INCINERATORS MEET TOMORROW'S REGULATIONS?** Preprint. (Presented at the 59th Annual Meeting, Air Pollution Control Association, San Francisco, Calif., June 20-24, 1966, Paper No. 66-131.)

Over the last two decades, Los Angeles, the San Francisco Bay Area, and other West Coast areas have gone far beyond most other parts of the country in the nature and extent of limitations legally imposed on incinerator design and performance. With the increasing population of these areas, and the problems of other solid waste disposal methods, it seems prudent to consider whether additional or tighter limitations may be imposed as rapidly as the technology permits. It is the purpose of this paper to consider briefly some of the implications of these possibilities. It is, therefore, primarily speculative in nature. Present and future standards for incinerator emission control, incinerator performance and design considerations are discussed. (Authors' abstract)

00582

M. Stratton

**EFFICIENT AND ECONOMICAL DISPOSAL OF COMBUSTIBLE WASTE MATERIALS BY 'BURNING IN SUSPENSION.'** Preprint. 1963

Incineration of combustible waste materials generated by wood processing industries is now being accomplished in a cyclotube incinerator. Combustion is so complete that most air-pollution requirements can be met with a minimum of secondary air cleaning or scrubbing equipment. The cyclotube principle can also be used in conjunction with disposal of any waste combustible from sludge materials to wastes developed by industry or municipalities. (Author's abstract)

00968

W. Jens and F. R. Rehm

**MUNICIPAL INCINERATION AND AIR POLLUTION CONTROL.** Proc. Nat. Incinerator Conf., New York, 1966, p. 74-

83, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 2-4, 1966.)

Three new concepts in municipal incinerator air pollution control developed jointly by City and County of Milwaukee personnel are described in detail. These concepts consist of a new impingement baffle fly ash collector system, an automatically controlled underfire-overfire air combustion control system and a water recirculation, clarification and neutralization system. A brief history of the development and evolution of these three new municipal incinerator control systems is presented. Comprehensive test data are presented on a municipal incinerator plant's total performance utilizing these three systems. The effect of varying capacity operation on the particulate emission performance of a municipal incinerator plant utilizing these control features is presented.

00975

M. I. Weisburd, (Compiler and Ed.)

**AIR POLLUTION CONTROL FIELD OPERATIONS MANUAL (A GUIDE FOR INSPECTION AND ENFORCEMENT).** Public Health Service, Washington, D. C., Div. of Air Pollution, 1962. 291p.

Author discusses sources, control methods, training techniques and related aspects of air pollution. Document is an excellent source for specific information on equipment being used in air pollution control. Pictures, diagrams, schematics and charts are given.

01064

R. L. Stenburg

**MODERN METHODS OF INCINERATION.** Air Eng. Vol 6:20-21, 34, Mar. 1964.

Basic combustion concepts in incinerator design and in firing practices are reviewed for emission control. Time, temperature, and turbulence requirements must be met for the complete burning of any material. Multiple-chamber designs, water-spray scrubbers, underfire air flow, fuel charging methods, and preheated combustion chambers are covered.

01437

E. R. Kaiser

**PROSPECTS FOR REDUCING PARTICULATE EMISSIONS FROM LARGE INCINERATORS.** J. Air Pollution Control Assoc., 16(6):324, June 1966.

Conventional types of municipal incinerators generate enormous quantities of stack gas because of high excess air and high temperatures. Under these conditions the size and cost of equipment to clean the flue gas to low dust contents are large. By burning the refuse in boiler furnaces at low excess air, and generating steam, the volume of flue gas to be cleaned is reduced to a minimum. Where high efficiency of flue-dust collection is required, steam generation from refuse firing permits a major saving on the cost of dust collection. (Author abstract)

01935

E. R. Kaiser

**COMBUSTION AND HEAT CALCULATIONS FOR INCINERATORS.** Proc. Natl. Incinerator Conf., New York, 1964. 81-9 pp.

The design of industrial and municipal incinerators is based on combustion and heat considerations. The procedures are given for calculating the quantities of air, flue gas, water, and heat, as well as the gas temperatures. To assist the reader, a

hypothetical municipal incinerator is used as an example. The relation between refuse analysis and flue gas analysis is explained. Sections on dry and wet dust collection are included. (Author abstract)

01936

H. G. Meissner

**THE EFFECT OF FURNACE DESIGN AND OPERATION ON AIR POLLUTION FROM INCINERATORS.** Proc. Natl. Incinerator Conf., New York 1964. 126-7 PP.

Control of air pollution from incineration begins in the furnace. Scientific design and careful operation will insure that the generation of pollution will be minimized. Effects of various criteria of design and operating practices are discussed. (Author abstract)

01937

A. B. Walker

**ELECTROSTATIC FLY ASH PRECIPITATION FOR MUNICIPAL INCINERATORS-A PILOT PLANT STUDY.** Proc. Natl. Incinerator Conf., New York, 1964.

Pilot plant test on a 220 ton-per-day continuous feed municipal incinerator demonstrates the technical feasibility of electrostatic precipitation for control of stack emission. Data on the nature of the furnace stack gases and the physical characteristics of the dust as well as performance of pilot unit treating approximately 600 cfm are presented. (Author abstract)

01938

E. M. Voelker

**ESSENTIALS OF GOOD PLANNING.** Proc. Natl. Incinerator Conf., New York City, 1964. pp. 148-52.

The growth of urban communities requires attention to the problem of solid waste disposal. The planning of facilities for incineration of the waste is the responsibility of the architect or engineer, while the manufacturer of the incinerator must supply equipment to meet the requirements. As an aid to this planning the Incinerator Institute of America sets forth eight points to be considered. These points cover questions of location, layout, air supply and draft, features of environment, and attention to local codes and ordinances. Number 7 of these points is entitled The Immediate Environments to Determine the Advisability of the Use of Auxiliary Equipment Such as Fly Ash, Collectors or Washers, Pyrometers, Secondary Burners, Draft Gauges, or Smoke Density Indicators, etc. In addition to these eight points, reference is also made to types of waste and some of the problems in handling and burning such wastes.

01939

G. Stabenow

**EUROPEAN PRACTICE IN REFUSE BURNING.** Proc. Natl. Incinerator Conf., New York, 1964. 105-13 pp.

The practice and type of design in some of the European municipal incinerators are described. Special attention is given to the design of grates. Data are given on the amount of refuse per capita, analysis of refuse, heat recovery, and some of the details of European design. The rigid European dust emission specifications of 0.15 to 0.25 lb./per 1000 lb. gas at 50% excess air make the use of electrostatic precipitators mandatory.

## B. CONTROL METHODS

33

01940

S. J. Pascual and A. Pieratti

**FLYASH CONTROL EQUIPMENT FOR MUNICIPAL INCINERATORS.** PROC. Natl. Incinerator Conf. New York, 1964.

A description is given of settling chambers with sprays, cyclone types and electrostatic precipitators as used in municipal incinerators. Special emphasis is placed on section and duct design, especially to inlets of collectors, which affect efficiency. Importance is stressed of preventing leaks and overfilling of hoppers and proper maintenance of equipment in order to obtain optimum efficiency. Control of air pollution is best accomplished by thorough burning in the combustion chamber thus decreasing the load to the flyash control equipment. (Author abstract)

01942

R. Goder

**INCINERATOR TESTING PROGRAMS.** Proc. Natl. Incinerator Conf., New York, 1964. pp. 157-60.

This paper is a discussion of the widely varied and uncoordinated efforts to study and evaluate incinerator design through field and laboratory tests and test programs. The incinerator industry has not been placed in its proper perspective. Air pollution, fire hazard and combustion efficiency are all elements requiring the specialists in each field to cooperate to produce a field standard acceptance test and on uniform terms and nomenclature for each assimilation of laboratory test data and reports. The emergence of air pollution problems into widespread public attention has directed attention upon the incineration of refuse in a degree that seems far more intense than the problem really requires -- at least in relation to other sources of air pollution. While incinerator industry has been steadily working to improve its equipment in all facts of performance, economy and operation many independent investigators in public and private agencies have embarked upon a program of study -- and in some instances research -- without a background of experience. The willingness, and desire, of the industry to cooperate with other interested professional groups is expressed by the author. He also calls attention to two publications on standards, both in 1963 by the Incinerator Industry by the Incinerator Institute of America. In the references of this paper the Interim Report of the Performance Evaluation Subcommittee of the APCA TA-3 Incinerator Committee on Test Methods for Determining Emission Characteristics, March 1963, is also noted.

01943

D. Schwartz

**LEXICON OF INCINERATOR TERMINOLOGY.** Proc. Natl. Incinerator Conf., New York City, 1964. pp. 20-31.

This lexicon was compiled for the use of a very diversified group of persons, including engineers, manufacturers, suppliers, builders and users, with interests in the field of incineration. The report was compiled from many sources in the hope that it would lead to a uniform lexicon which would be adopted by all interested groups. Types of refuse are categorized into 6 different groups, and classes of incinerators into 7. The definitions that follow are then intended to have general applicability for these classes of incinerators and types of refuse. For terms not defined in this lexicon, it is suggested that the reader consult a standard dictionary or engineering handbook. For convenience the definitions have been divided into categories as follows: Refuse and products of incineration; General design; Refractories and furnace construction;

Grates -- manual and mechanical; Materials handling; Burners and instruments; and Miscellaneous.

01944

R. L. Stenburg

**MODERN INCINERATION OF COMMUNITY WASTES.** Proc. Natl. Incinerator Conf., New York City, 1964. pp. 114-7.

Incineration is gaining as a means of disposing of solid waste in both municipal and smaller units. There is, however, an air pollution problem involved. Knowledge of technology of design and operation are necessary for good results with a fuel having such a wide range of characteristics. Helpful present trends in design and operation include the adopting of continuous charging, use of multiple combustion chambers, maintaining furnace temperature, and control of particulate matter. (Author abstract)

01945

L. S. Wegman

**PLANNING A NEW INCINERATOR.** Proc. Natl. Incinerator Conf., New York City, 1964. 1-7pp.

When a municipality is to build an incinerator, two major questions are capacity and location. The capacity is a function of area and population to be served, the future years for which to design, and the volume of the waste, with due regard to the changing character of waste material. Factors to consider in selecting location include length of haul, topography of a proposed site, and utilities available. Other considerations are prevention of air and water pollution, subsoil explorations, residue disposal, storage bin size, and costs. (Author abstract)

01946

F. J. Lynch

**PROBLEMS ENCOUNTERED IN THE OPERATION OF A LARGE INCINERATOR PLANT.** Proc. Natl. Incinerator Conf. New York, City, 1964. 132-4 pp.

Problems encountered at various points in an incinerator are described. The scale is sometimes too small; dust and fires in the storage bin may be a problem; and attention must be given to maintenance of refractory in ignition and combustion chambers. Instrumentation is sometimes overdone. There may be ignition and air supply problems in furnace operation; cranes need careful maintenance; provisions for burning large objects may be available; and removal of fly ash and residue need further study. (Author abstract)

01947

E. R. Kaiser

**REFUSE COMPOSITION AND FLUE-GAS ANALYSES FROM MUNICIPAL INCINERATORS.** Proc. Natl. Incinerator Conf., New York City, 1964. pp. 35-51.

This study was undertaken to obtain more understanding of the refuse charged into municipal incinerators and of the combustion process as revealed by analyses of combustion gases. Analyses of refuse components were collected from numerous sources, from which a composite refuse analysis was calculated. This average refuse was not presented as a national average but, in the absence of better data, it was a useful basis for evaluating the gas analyses and the incineration process. By comparison with theoretical gas analyses from the composite refuse, a number of conclusions could be reached, and these are given in some detail in this study. A marked difference was noted between the analyses of the stack gases and those to be expected from the combustion of the composite



refuse. Much of the differences can be accounted for by the carbon loss in the residue and oxidation of metallics. Appendix D gives the data on the flue-gas analyses of 18 municipal incinerators. Appendix E gives the data on the analyses of the flyash (weight per cent) produced by three different incinerating plants.

02027

C. Cederholm

**COLLECTION OF DUST FROM REFUSE INCINERATORS IN ELECTROSTATIC PRECIPITATORS PROVIDED WITH MULTICYCLONE AFTER-COLLECTORS.** Proc. (Part I) Intern. Clean Air Cong., London, 1966. (Paper V/3) pp. 122-5.

Until a few years ago electrostatic precipitators were used merely for collection of dust from refuse incinerators. Difficult problems were encountered due to the emission of paper flakes, despite maintaining guaranteed collection efficiencies. The difficulty in collecting the paper fraction in an electrostatic precipitator is due to the large area of these particles and their low specific gravity, which in combination with low resistivity increases the chance of the particles passing through the precipitator without adhering to the collecting electrified and also of being whirled back into the gas stream when the electrified are rapped. Reliable collection of the paper fraction could probably be achieved by oversizing the electrostatic precipitator or by greatly reducing the gas velocity in the precipitator. In view of the wide variations in paper content, which will be highly increased in the future, it is very difficult to determine the percentage of paper in refuse. As a result the oversizing must be increased to unreasonable proportions. In our efforts to find an alternative solution we have combined electrostatic precipitators with specially designed multi-cyclone after-collectors, for which purpose the precipitator casing has been extended by about 1.5 m and the full section utilized for the installation of small cyclones. Interesting trial results have been obtained from such installations now in operation in both Switzerland and Sweden.

02153

C. A. Rogus.

**CONTROL OF AIR POLLUTION AND WASTE HEAT RECOVERY FROM INCINERATION.** PUBLIC WORKS 97, (6) 100-3, JUNE 1966.

Europe has had for some time rigid government standards controlling air pollution with many large scale air pollution control installations, particularly of refuse incineration facilities. The nature of air pollutants from refuse incineration is discussed. The chemical analysis of fly ash is given as well as the size distribution of stack dust emissions. Air pollution abatement equipment is described. The approximate characteristics and costs of major collector systems are tabulated.

02186

R. L. Stenburg.

**STATUS OF THE FLUE-FED INCINERATOR AS A SOURCE OF AIR POLLUTION.** Am. Ind. Hyg. Assoc. J., 24, 505-16, Oct. 1963.

Flue-fed incinerators are discussed as a source of air pollution. Design and operating factors responsible for the air pollution problems are presented with alternative modifications for improvement. Recommendations are included for modification of existing units and improved design of new installations. Alternative methods of refuse disposal are considered also. (Author abstract)

02232

R.L. Stenburg, T.P. Hangebrauck, D.J. Von Lhmden, A.H. Rose, Jr.

**EFFECTS OF HIGH VOLATILE FUEL ON INCINERATOR EFFLUENTS.** J. Air Pollution Control Assoc. 11, 376-83, Aug. 1961 (Presented at the 53rd Annual Meeting, Air Pollution Control Association, Cincinnati, Ohio, May 22-26, 1960.)

A readily vaporizable solid fuel normally considered as being more difficult to burn than ordinary cellulose was treated in a multiple chamber incinerator having an 8.5 sq. ft. grate area in a 19.5 cu. ft. primary combustion chamber, a downpass mixing chamber and a 16.5 cu ft. final combustion chamber. One part shredded asphalt saturated felt roofing composed of 60% petroleum base asphalt, 37 1/2% felt, and 2 1/2% ash with one part 4" squares of newspaper was the fuel mixture. The effects of combinations of excess air (100 and 200%), fuel feed rate (100 and 150 lb/hr), fuel per charge, underfire air (15 and 60%), and secondary air on the emission of particulates, oxides of nitrogen, hydrocarbons, carbon monoxide, formaldehyde, and smoke were evaluated. Optimum conditions imply a temperature range of 1800 to 2000 F in the secondary chamber, 15 to 20% underfire air, and small batch on continuous charging.

02387

R. L. Bump.

**THE USE OF ELECTROSTATIC PRECIPITATION FOR INCINERATOR GAS CLEANING IN EUROPE.** Proc. Natl. Incinerator Conf., New York, 1966. 161-6, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

Electrostatic dust precipitators of high efficiency are widely used in Europe to clean the flue gas from incinerators. The basic principles of design and the factors for successful application of Lurgi units are explained. A list of installations is included which states the efficiencies attained. All types of dust collectors are compared, based on U.S. costs. (Author abstract)

02388

V. J. Cerniglia.

**CLOSED-CIRCUIT TELEVISION AND ITS APPLICATION IN MUNICIPAL INCINERATION.** Proc. Natl. Incinerator Conf., New York, 1966 187-90, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

Closed-circuit television has been applied to a municipal incinerator plant with two 250-ton-a-day furnaces. Two cameras monitor the storage pit and crane operation, while one camera watches the fire in each furnace. The plant supervisor, at his monitoring control station, has controls at his fingertips affecting all critical operation of the plant, such as overfire air and water spray control, as well as indicators showing the effect of draft, temperature, and air pollution control. Available also is a public address system which reaches throughout the plant. The paper discusses the features of the equipment, the costs, and the advantages. (Author abstract modified)

02389

J. A. Challis.

**THREE INDUSTRIAL INCINERATOR PROBLEMS.** Prog. Natl. Incinerator Conf. New York, 1966 208-18, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

Case histories are presented for the disposal by incineration of three types of chemical wastes, which required auxiliary fuel for their combustion. The wastes include a carbon/water slurry, a highly colored liquid waste generated during TNT manufacture, and a gas containing hydrogen sulfide. These three examples of waste disposal fall into the category of incineration. This means that persons engaged in formulating some guide lines for industrial incineration are faced with a considerably wider problem than their counterparts in the municipal or domestic waste incineration fields. It is reasonable to observe that the industrial cases are legion and they are all open to solution by the laws of heat and mass balance. Thus, while it may not be possible to draw up rigid incinerator specifications, it should be possible to recommend an acceptable common language for describing the composition and enthalpy of the input wastes. It would also be desirable to obtain common acceptable units and limits for the oxidation products, which may be gaseous, as carbon dioxide, sulphur dioxide, etc., or liquid, from leached-out fly ash or other soluble salts. (Author abstract)

02390

H. Eberhardt.

**EUROPEAN PRACTICE IN REFUSE AND SEWAGE SLUDGE DISPOSAL BY INCINERATION.** Proc. Natl. Incinerator Conf. 124-43, 1966. Combustion 38, (4) 23-9, Oct. 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

American and European incineration starts from two different prerequisites. In America, volume reduction of the refuse is strived for; in Europe the aim is to completely burn out the refuse, to utilize the waste heat, and to minimize air pollution as far as possible through the use of expensive flue-gas cleaning equipment. Today, values that must be attained are 3 per cent combustible constituents in the residue, 0.1-0.2 per cent putrefying substance, and 0.04 grains of dust per std cu ft of flue gas. The combination of refuse incineration and large power station boilers is becoming more and more frequent. This can be attributed to the favorable financing possibilities by the States for electric companies with additional incineration of household and industrial refuse. This explains development of large boiler plants with high steam temperatures and pressures which have been combined with refuse incineration. Possible corrosion problems seemed formidable at first, but today means are available to substantially prevent such damage and to improve the availability of combined refuse boiler units. (Author abstract)

02394

E. W. Haedike, S. Zabodny, and K. S. Mowbray.

**AUXILIARY GAS BURNERS FOR COMMERCIAL AND INDUSTRIAL INCINERATORS.** Proc. Natl. Incinerator Conf. 235-40, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

The use of gas burners to supply auxiliary heat to commercial and industrial incinerators is helpful in control of air pollution and general performance. The paper discusses the design and applications of gas burners in this service. Burner pilots and safety controls are described. (Author abstract)

02396

E. S. Monroe.

**NEW DEVELOPMENTS IN INDUSTRIAL INCINERATION.** Proc. Natl. Incinerator Conf. 226-30, 1966. (Presented at the

National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

The paper is a review of improved calculating and design techniques, performance rating of incinerators, and a description of the new open-pit incinerator. Of particular interest is a curve of nitrogen oxide formation with varying excess air and temperature developed from thermodynamic equilibrium data that has been verified by field tests. (Author abstract)

02397

C. A. Rogus.

**AN APPRAISAL OF REFUSE INCINERATION IN WESTERN EUROPE.** Proc. Natl. Incinerator Conf. 114-23, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

Europe's incineration of community refuse has reached an advanced state of the art. The author visited 13 large modern incinerators in 7 countries. The three most noteworthy operating plants are described, with emphasis on steam generation, low dust emission from the stacks, and principal features of design. Applicability to American practice is evaluated. (Author abstract)

02398

G. Stabenow.

**SURVEY OF EUROPEAN EXPERIENCE WITH HIGH PRESSURE BOILER OPERATION BURNING WASTES AND FUEL.** Proc. Natl. Incinerator Conf. 144-60, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

A number of large incinerators in European municipal service have stoker-fired water-walled furnaces and boilers for power generation. The paper discusses the principles, stoker design, burning rates, boiler design and high efficiency dust collection. Data on nine European and two Brazilian plants of European design are given. Water-walled furnaces allow the use of low excess air, which reduces the volume of flue gas to be cleaned. (Author abstract)

02399

J. W. Stephenson and A. S. Cafiero.

**MUNICIPAL INCINERATOR DESIGN PRACTICES AND TRENDS.** Proc. Natl. Incinerator Conf. 1-38, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

Improvements and changes in refuse incinerator technology during the past twenty years have been greater than in any other period. This paper reports the findings of a survey of design practices covering plants built or designed since 1945. Data are presented on 205 plants for which questionnaires were returned, with notations made of indicated trends in design practices and types of equipment. Eighty-four plants, for which questionnaires were not returned, are listed in the third appendix. It was noted that, since 1959, no plants were reported as designed without some provision for fly ash removal. A trend away from reliance on dry expansion chambers for satisfactory removal is clearly evident, as is a trend to the use of wet systems. Fifty-three of the reported 71 wet systems included wet baffles, with primary material of baffle construction given in a table in the text.



02400

A.B. Walker F.W. Schmitz

**CHARACTERISTICS OF FURNACE EMISSIONS FROM LARGE MECHANICALLY STOKED MUNICIPAL INCINERATORS.** Proc. Natl. Incinerator Conf. 64-73, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

A summary of field test and laboratory data on dust emission from several large, mechanically-stoked municipal incinerators of different grate configurations is presented. Data on dust loading, and physical and electrical characteristics of the particulates are presented, as well as information on combustion conditions in the furnace. Description of field test equipment and techniques, and techniques of laboratory analysis are given. (Author abstract)

02401

P.H. Woodruff A.W. Wene

**GENERAL OVERALL APPROACH TO INDUSTRIAL INCINERATION.** Proc. Natl. Incinerator Conf. 219-25, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

A detailed outline has been prepared to guide and advise industry in planning a safe and economical facility for waste disposal. Among the factors to consider are types and quantities of gaseous, liquid, and solid waste, methods of collection, transportation, storage, and disposal. As a method of disposal, incineration is discussed in detail. Among the subjects discussed are site, selection, meteorological conditions and air pollution control requirements, ash-handling system, and atmosphere emission control.

02402

G.L. Vickerson

**FLY ASH CONTROL EQUIPMENT FOR INDUSTRIAL INCINERATORS.** Proc. Natl. Incinerator Conf. 241-5, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

A description is given of the problem facing the engineer when designing an industrial incinerator, referring especially to the treatment of particulate emissions from the incinerator between 35 and 200 microns in size, and the choice of available commercial equipment which can attain the required results. (Author abstract)

02488

C. N. Stutz.

**TREATING PARATHION WASTES.** Chem. Eng. Progr. 62, (10) 82-4, Oct. 1966.

Pilot plant tests were made of parathion wastes combined with domestic wastes to assure the city that the wastes can be treated successfully in the municipal activated sludge treatment plant. Expansion of the parathion plant requires the development of design criteria for a pretreatment plant. Incineration of residues and scrubbing and demisting of the off-gases are practical. Limestone neutralization of the acid streams followed by blending with alkaline streams before biological treatment is used to control the pH.

02738

J. A. Fife

**CONTROL OF AIR POLLUTION FROM MUNICIPAL INCINERATORS.** Proc. Natl. Conf. Air Pollution, 3rd, Washington, D.C., 1966. pp. 317-26.

The background and development of air pollution control as applied to municipal incinerators is reviewed. The capabilities and characteristics of the several types of systems currently in use are explained, and an indication of the variables affecting their costs is given. The text also includes suggestions as to areas where further research study in the field would be beneficial, and points out specific problems currently hindering progress.

02741

Golucke, C. G., and P. H. McGahey

**FUTURE ALTERNATIVES TO INCINERATION AND THEIR AIR POLLUTION POTENTIAL.** Proc. Natl. Conf. Air Pollution, 3rd, Washington, D.C. 1966. (Presented at the National Conference on Air Pollution, Washington, D.C., Dec. 12-14, 1966, Paper No. D-6.) p. 296-305.

The alternatives to incineration are almost entirely limited to landfill, composting, anaerobic digestion, ocean disposal, wet oxidation, and pyrolyzation. All these require essentially the same handling methods as are associated with preparing refuse for incineration. Hence, dust, vapors, and odors may be a local air pollution problem in the vicinity of the processing site. Thus, offense to the aesthetic senses rather than danger to the health of men and animals, or damage to vegetation, might be considered a micro-air pollution potential common to all methods. The alternative processes themselves, if properly operated, make little further contribution to air pollution. Even with poor management their pollution potential is confined to odors, dust, and some vapors, with the possible exception of pyrolysis which could rival incineration if poorly managed. An evaluation of alternatives to incineration as methods of refuse disposal should be based on at least three major considerations: (1) It is no longer valid to judge (evaluate) a given method according to the rather limited standards currently followed. At present, the economics of a process constitute the major concern; other factors such as health and aesthetics are given only grudging attention. A realization of the direct bearing of man's environment upon his well being is beginning to emerge and the willingness to expend more effort and money in maintaining the integrity of the environment will follow. (2) It will be impossible for the human species to continue present rates of population increase, present rates of increase per capita consumption of goods, and simultaneously maintain an environment in which waste products do not become ultimately totally inhibitory to life. Consideration must be given to methods for total recycling of all materials consumed and subsequently discharged. (3) Only the land and ocean can be looked upon as ultimate sinks into which solid wastes can be discharged. At present, there is no method of disposal, except dumping at sea, that does not return a large fraction of solid wastes to the land. An important aspect of a future method will be the extent to which its application can reduce this ultimate burden to the land.

02976

G. Albinus

**REDUCING THE EMISSION OF SMALL WASTE INCINERATORS BY STRUCTURAL AND CONTROL MEASURES.** Staub (English Transl.) 25, (11) 17-20, Nov. 1965. CFSTI TT66-51040/11



The causes of defective refuse incinerations are given and a possibility of reaching a satisfactory emission reduction is shown. The importance of secondary incineration and reliable maintenance of incineration plants is emphasized in particular. The influence of combustion temperature on furnace design is explained for a temperature range of 800 degrees C to 1000 degrees C. To maintain optimum temperature ranges and to control air supply is much more important in refuse incineration than is generally thought. Dust removal installations are discussed and successful results achieved with wet separators are reported. (Author summary)

03229

Z. Syrovatka

**NEW INCINERATION SYSTEM FOR TOWN REFUSE.** Czech Heavy Ind. (Prague) 11, 15-8, 1966

Boilers for the combustion of refuse have been constructed in Prague, Czechoslovakia. Since varying types of refuse must be disposed of, and since the material must be pre-dried, pre-heated, ignited at the proper time, and properly burnt out, problems exist. Perfect combustion is important in ensuring that the combustion products ultimately discharged are harmless. The incinerator system is described in detail. The combustion products pass through filters and an electrostatic precipitator before reaching the stack. The slag is sterile and the smoke from the chimney harmless. Clean air is maintained.

04843

P. W. Purdom, R. J. Schoenberger, A. Michaels, and A. Bergsten

**INCINERATOR RESIDUE - A STUDY OF ITS CHARACTERISTICS.** Preprint. (Presented at the Public Works Congress and Equipment Show, Chicago, Ill., Sept. 10-15, 1966.)

The quality of incinerator residue does vary significantly, and therefore, should be recognized as a criterion for design and operation. Preliminary field investigations indicate that incinerator residue can attract flies and under proper conditions propagation will occur. The percent of water soluble material is significant enough to justify a detailed investigation of the effects of this leachable portion on the surface and underground waters. In order to evaluate the effectiveness of an incineration process, chemical analyses can be used as a means of monitoring. Although many chemical techniques are available for classifying incinerator residue, it appears that effectiveness can be measured from a few simple tests. The two tests which are suggested are the calorific value and either the volatile or ash fraction of the residue. For larger installations, the more detailed system of analyses can be used to monitor the units.

05498

A. B. Walker

**AIR POLLUTION CONTROL EQUIPMENT FOR INCINERATORS.** Proc. MECAR Symp., Incineration of Solid Wastes, New York City, 1967. pp. 75-81.

A picture is presented of where the technology of air pollution control stands with respect to the primary needs in incineration namely, the control of particulates based upon what is known from actual operating experience, either pilot or full scale, with various types of control equipment. Reasonable performance expectations are presented for various control equipment based upon this actual operating experience and the rather substantial amount of work that has been done in the past few years. Unless furnace operation is restricted significantly, particularly with respect to underfire air, settling cham-

bers or wetted baffles cannot meet even the most lenient quantitative emission code (0.85) either alone or in combination. Cyclone collectors alone can probably meet 0.85 and probably, in combination with settling chambers and/or wetted baffles, can meet intermediate codes. But where codes require emissions below 0.65, the only demonstrated alternatives are direct impaction scrubbers, electrostatic precipitators or bag filters. For clear stacks, the only demonstrated alternatives are electrostatic precipitators and bag filters, although direct impingement scrubbers operating at pressure drops in excess of 10' w.g. and equipped with means for eliminating condensate plume, are probably feasible, based on valid extrapolation of actual operating experience, the choice of which depends upon a detailed analysis of the economics and operational reliability of the over-all system involved in utilization of each type. Generalizations on the best system cannot be made at this time, but, at least for new plants, operational experience and economics seem to favor the electrostatic precipitator.

05569

E. C. Mirus

**NATIONAL ANILINE'S INCINERATION PLANT.** Proc. Air Water Pollution Abatement Conf., 1957. pp. 76-82.

A description of the incinerators used in the disposal of rubbish resulting from manufacturing operations at National Anilines's Buffalo plant were outlined. The operations, maintenance, and a system for disposal control are also included.

05570

R. F. Rocheleau

**INCINERATION OF ORGANIC WASTES (SLUDGES AND CHEMICALS).** Proc. Air Water Pollution Abatement Conf., 1957. pp. 89-98.

The general features and operating problems of representative incinerators used in du Pont are presented. Generally speaking, incineration looms as a potential method of disposal when solid wastes cannot be transported to a dump for burial, when liquid wastes containing volatile compounds or an appreciable amount of combustible organic matter cannot be discharged to a water course, or when the gases emitting from a process cannot be released directly to the atmosphere. The variety and multiplicity of wastes and the needs peculiar to each plant location dictate that each installation must be a custom-built job.

05852

R. J. Reed and S. M. Truitt

**SELECTING INCINERATOR SMOKE AND ODOR BURNERS.** Air Repair 4 (3), 109-17 (Nov. 1954).

A method for controlling smoke and odor emission by flue-fed incinerators is discussed. The burning process, the differences from industrial and municipal incinerators, a solution using an auxiliary gas diffusion flame, the selection and location of burners, a case history of an approved installation, settling and combustion chambers, the luminous flame burner, starting procedure, and recently announced installations are considered. A discussion and the authors' replies are included.

05874

M. Sterling

**AIR POLLUTION CONTROL AND THE GAS INDUSTRY.** J. Air Pollution Control Assoc. 11 (8), 354-61 (Aug. 1961). (Presented at the American Gas Association Research and Utilization Conference, Cleveland, Ohio, Apr. 19-21, 1960.)

The control of emissions from gas fired domestic incinerators in Detroit, Michigan was discussed. To insure that incinerators perform acceptably, the sale of domestic incinerators is limited to those models which pass performance requirements of the Detroit Bureau of Air Pollution Control. The discussion includes the development of regulations, performance requirements, design features of new incinerators and testing apparatus and procedures.

06084

R. J. MacKnight, J. E. Williamson, J. J. Sableski, Jr., J. O. Dealy

**CONTROLLING THE FLUE-FED INCINERATOR.** J. Air Pollution Assoc. 10(2):103-109; 125, (Apr. 1960) (Presented at the 52nd Annual Meeting, Air Pollution Control Association, Los Angeles, Calif., June 23-26, 1959.)

A series of tests were conducted in order to compare the burning rate, draft, velocity, and temperature in an uncontrolled incinerator with those variables in the same incinerator equipped with a ring-fired roof afterburner and draft control damper. A set of three tests was made on a six story flue fed incinerator under the following conditions. (1) The incinerator was modified with a draft control damper (orifice area 30 sq. in.) and ring-fired roof afterburner. (2) The baffle in the settling chamber of the afterburner was removed to simulate an afterburner with no settling chamber. (3) The unit was operated as an uncontrolled flue fed incinerator with the draft control damper lowered, the baffle in the settling chamber removed, and the roof burner not in operation. The results of the stack analyses in pounds per ton are: Uncontrolled flue fed incinerator-30; Afterburner and draft control damper-3.3; and Afterburner, draft control damper and settling chamber-3.0. The draft control damper reduces emissions so that a settling chamber is not needed. There are two satisfactory methods of controlling the flue fed incinerator: (1) by breeching a separate multiple chamber incinerator into the existing flue and conversion of the existing combustion chamber into a storage bin, and (2) by installation of an afterburner on the flue above the roof and a draft control damper below the first floor charging chute. Installation of a roof afterburner and draft control damper has the advantage of permitting the refuse to be burned in the original flue fed incinerator. Thus, the refuse does not have to be rehandled. By incorporating a motorized damper and complete electrical interlocking system the unit becomes very simple and convenient to operate.

06096

F. R. Rehm

**INCINERATOR TESTING AND TEST RESULTS.** J. Air Pollution Control Assoc., 6(4):199-204, Feb. 1957. 2 refs. (Presented at the 49th Annual Meeting, Air Pollution Control Assoc., Buffalo, N. Y., May 20-24, 1956.)

The testing of particulate emissions from incinerators of any size, from domestic to municipal units presents some special problems peculiar to this activity. The shortcomings of two dust testing guides ((ASME Test Code for Dust Separating Apparatus and Western Precipitation Corporation's Bulletin WP-50 Gas and Dust Measurements)) for testing particulates from such units are discussed in detail. Modifications made in the ASME guide in an incinerator testing program in Milwaukee, Wisconsin are also indicated. The incinerator test program indicates that commercial and industrial incinerators that incorporate in their design the following fundamental features can operate below the ASME dustloading limitations: a. Primary and secondary chamber. b. Increased retention time accomplished by drop curtain or baffle construction. c. Reduced

secondary chamber velocities. d. Built-in and auxiliary draft regulation. e. Proportioning of the unit to regulate capacity, flow and temperature conditions. These design features are also encouraged for use in domestic incinerators. A well-designed wet scrubber flyash control system has made municipal incinerator compliance with the strictest air pollution ordinance possible. A municipal incinerator plant in Milwaukee has been modified to include a wet flyash scrubbing system that yields an average exit dustloading of 0.692 lb. dust/1000 lb. flue gas, adjusted to a 50% excess air basis. ASME recommends 0.85 lb/1000 lb flue gas adjusted to a 50% excess air basis as the limit on dust emissions.

06315

R. Dennis, L. Silverman

**SUMMARY REPORT ON PERFORMANCE OF AIR CLEANING SYSTEM FOR U.S. BUREAU OF MINES BOMAEC-30 INCINERATOR.** Harvard School of Public Health, Boston, Mass., 156p., Dec. 1964. (Rept. NYO 841-2.) (Contract AT(30-1)-841.)

Evaluation of combustion and gas cleaning equipment tests are presented on the BOMAEC-30 institutional type incinerator developed for low level, radio-active waste disposal. In contrast to many incinerator designs, the BOMAEC-30 unit consisted of a cylindrical, stainless steel-lined, chamber with all combustion air admitted tangentially above the waste charge. Although this burning technique may have improved the effluent quality, results of several tests with sawdust and office wastes indicated that (a) only dry (less than 10 per cent moisture) materials could be burned completely without auxiliary gas firing, (b) the design burning rate objective of 30 lbs. per hour could not be attained in most tests, and (c) the operating methods were not amenable to a safe, rapid means of waste incineration. A water spray cooling tower and glass fabric filtration system did not furnish adequate gas cleaning. Aside from bag filter rupture caused by soot plugging, moisture and condensed volatiles passing the glass bag unit did not appear filterable with final, AEC high efficiency stage. The data presented in this report do not agree with the conclusions and claims set forth in a report, R.I. 6083, issued by the U. S. Bureau of Mines. Two appendices are included on stack effluent tests on BOMAEC-30 and BOMAEC-100 incinerators.

06588

J. A. Fife

**REFUSE DISPOSAL AND THE MECHANICAL ENGINEER (COMPOUNDING PROBLEMS PROMISE A MAJOR ROLE FOR THE MECHANICAL ENGINEER).** Heating, Piping, Air Conditioning 38(11):93-100, Nov. 1966.

Refuse disposal methods in the United States and Europe are presented, the emphasis being on incinerator design improvements. The replacement of incinerator batch feeding with continuous feeding (eliminating blanketing of fire and uncontrolled admissions of air, thus keeping furnace temperature and flue gas flow rates more uniform) is reviewed. An advantage of the continuous feed furnace occurs from the relatively steady flow of output flue gas, enabling rational sizing of improved fly ash collectors. Under certain conditions, fly ash collection can be accomplished by spray chambers in which flooded baffles are provided to trap ash particles by direct impingement on the wetted surfaces. Different economic conditions, denser settlement of cities, and a greater interest in heat recovery and air pollution control has put European incineration state-of-the-art ahead of the United States. As air pollution control requirements become increasingly stringent, more expensive fly ash collecting systems will be required in the United States. The



## B. CONTROL METHODS

39

use of mechanical cyclone and electrostatic precipitator equipment, in contrast to the water spray type collection systems will generate a favorable economic situation for the water-cooled furnace. Mechanical engineering services will be required during construction, inspection, and operation of these future developments.

07426

H. Mandelbaum

**AIR-POLLUTION STUDIES AT THE NEW PLANT IN THE TOWN OF NORTH HEMPSTEAD PROVE THAT INCINERATORS CAN MEET TOUGHER STANDARDS.** Am City, 82(8):97-98, Aug. 1967.

Comprehensive tests have confirmed that the new incinerator built for the town of North Hempstead, N. Y. has an air pollution control train (consisting of secondary combustion chamber, a low-velocity expansion or cooling chamber, four banks of high pressure water sprays, a secondary baffle chamber and finally the cyclone collectors) that meets existing and proposed air pollution control requirements. It has been designed so that further improvements in efficiency can be made easily if the need arises.

07769

Howard, W. C.

**A NEW AND ECONOMIC SOLUTION TO THE PROBLEMS OF STREAM AND AIR POLLUTION.** Norsk Skogind. (Norway), 21(4):133-139, April 1967. 2 refs. (Presented at the Papirindustriens Tekniske Forenings Meeting, Oslo, Norway, Dec. 7, 1966.)

The disposal of polluting solids by means of the fluid-bed reactor is discussed. The fluid-bed reactor is the most efficient combustion system developed thus far. Material is introduced in finely divided form, presenting relatively large surface area for exposure to the reacting gases. Heat transfer is excellent because of extreme particle proximity. Liquids of low concentration burn readily because of countercurrent evaporation which takes place during the liquid particle's descent to the fluid bed. The fluid bed reactor is relatively compact, occupying less area than other conventional processing units with comparable capacity. Operations of chemical recovery systems, the kraft overload relief system, and incineration systems utilizing the fluid bed reactor as the primary processing unit are described. In addition to accomplishing a system for disposing of objectionable effluent materials from plants, the fluid-bed is a practical tool for the reclamation of chemicals where practical. Other applications include disposal of pickling wastes from the metals industries, municipal sewage sludge disposal, food processing plant discards and effluent waste materials from the chemical and petroleum processing plants.

07921

Benforado, David M., Pauletta, Carl E., and Hazzard, Noel D. **ECONOMICS OF HEAT RECOVERY IN DIRECT-FLAME FUME INCINERATION.** Air Eng., 9(3):29-32, March 1967. 3 refs.

Direct-flame fume incineration as an effective and economical air pollution control process is discussed. Its advantages over thermal incineration without a flame, its use in conjunction with heat recovery equipment are topics also covered. Direct-flame incineration, economy of heat recovery equipment, practical solution to air pollution problem, control equipment requirements, design criteria, information required by equipment manufacturer and measurement of effectiveness of equipment are also discussed.

07973

Davis, U. C.

**THE FOOD PROTECTION AND TOXICOLOGY CENTER.** Bionomics Briefs, 1(5):1-14, Sept. 1967.

The environmental quality, natural and man made, and how this quality may be preserved through study, research and the teaching of values is discussed. The San Francisco garbage problem is reviewed; the problems of its disposal in the neighboring city of Brisbane are given. Included are reports and recommendations from several committees established by state and Federal governmental agencies to investigate improved methods of coping with the waste crisis. Garbage disposal by the use of land-fills, incineration, garbage trains, sea dumping, and composting is evaluated along with other published information on the facets of urban garbage disposal.

08178

Belousov, S. P., A. S. Dun, and I. I. Nikberg

**THE USE OF BATTERY COMBUSTION CHAMBERS IN THE PURIFICATION OF INDUSTRIAL EMISSIONS INTO ATMOSPHERIC AIR.** Gigena i Sanit., 24(4):70-71, 1959. Translated from Russian by B. S. Levine, U.S.S.R. Literature on Air Pollution and Related Occupational Diseases, Vol. 4, p. 54-56, Aug. 1960. CFSTI: TT 60-21913

The gas purifying installation described is of the type used in a Soviet coke-pitch plant. The coke was roasted in batteries of open flame furnaces of the 0Yuzhkokremont0 system; each battery consisted of 10 15 open flame furnaces. Reconstruction of the battery furnaces was carried out which consisted in rebuilding part of the furnace into purification installations of the supplemental combustion chamber type. Thus, the exhaust gases coming from the furnace flues were passed through the supplemental combustion chambers before entering the smokestacks. The supplemental combustion of pitch-coke waste products is accomplished at 1150 - 1500 deg. This high temperature is attained by sucking in extra air through special openings in the supplemental combustion chamber.

08632

Kirov, N. Y.

**EMISSIONS FROM LARGE MUNICIPAL INCINERATORS AND CONTROL OF AIR POLLUTION.** Clean Air Air Soc. Australia New Zealand, 1(2):19-25, Sept. 1967. 7 refs.

Emission and emission limits for refuse burning incinerator plant are discussed in relation to various Clean Air Acts. Methods of controlling these emissions and the type of equipment available for cleaning combustion gases from incinerators are outlined. USA and European practices in controlling air pollution from incinerators are critically compared, showing that in this regard European developments are well ahead of current American practice. The performance of various gas-cleaning equipment is examined and it is concluded that for large municipal incinerators only fabric gas filters, wet gas scrubbers, and electrostatic precipitators are capable of achieving the high-collection efficiencies necessary for effective control within the requirements of the NSW Clean Air Act. (Authors abstract, modified)

08727

**DUST REMOVAL IN REFUSE INCINERATOR PLANTS.** ((Mullverbrennungs- anlagen und deren Enstaubung.)) Text in German. Wasser Luft Betrieb (Mainz), 8(7):426-428, July 1964. 5 refs.

In refuse incinerator systems which utilize the heat, dust removal does not present difficulties, since the flue gas tem-



perature be hind the boiler ranges between 120-300 deg. C. However, in smaller plants a dust removal apparatus is necessary. Both dry and wet dust removal has been used. Experience with American air filters has shown that wet dust remover ROTO-CLONE and the fly dust remover AMER-clone as well as the DUSTBOX and AMERITHERM dust removers can be installed. An incinerator used for the incineration of paper was fitted with an AMER-clone filter. Measurements showed that the dust concentration before dust removal was 210 mg./normal cu m, while after filtration it was only 36.9 mg./normal cu m. It was concluded that crude gas with dust concentration of not more than 1,000 mg./normal cu m can be controlled by this method. To control larger dust concentrations, experiments were conducted with a silicon glass fiber bag filtering apparatus, which is illustrated. An air stream of 640 cu m/hr. was passed through the glass fiber bag at a temperature of 260 deg. C. Measurements showed that the dust concentration in the unfiltered gas was 30.8 g./cu m, while only 0.071 g./cu m was found in the filtered gas. The hose was cleaned every half-hour under reduced pressure. The exhaust gas plume which was noticeable after wet filtration was not observed by this method. Since it was established that this plume consists mainly of SO<sub>3</sub>, further tests showed that the SO<sub>3</sub> content of 97.5 mg./cu m in the unfiltered gas was reduced to 5.7 mg./cu m by filtration through siliconized glass fabric.

08837

Kane, J. M.

**STATUS FORECAST FOR AIR POLLUTION CONTROL - 1972.** *Air Eng.*, 9(3):33-34, 37, March 1967.

A forecast of what will happen in the field of air pollution control in the next five years is presented. The pollutants covered are smoke, visible dusts, visible plumes, hydrocarbons, diesel engine fumes and smokes, and oxides of sulfur.

09784

Danielson, John A. (comp. and ed.)

**AIR POLLUTION ENGINEERING MANUAL. (AIR POLLUTION CONTROL DISTRICT, COUNTY OF LOS ANGELES.)** Public Health Service, Cincinnati, National Center for Air Pollution Control, PHS-Pub-999-AP-40, 999-AP-40, 892p., 1967. ((314)) refs. GPO: 806-614-30

The control of air pollution at individual sources peculiar to the Los Angeles area is considered. The practical engineering problems of design and operation for many sources of air pollution are emphasized. There are 11 chapters, each by different authors, and 4 appendixes. The chapter titles are: (1) Introduction; (2) Contaminants; (3) Design of Local Exhaust Systems; (4) Air Pollution Control Equipment for Particulate Matter; (5) Control Equipment for Gases and Vapors; (6) Metallurgical Equipment; (7) Control Equipment; (8) Incineration; (9) Combustion Equipment; (10) Petroleum Equipment; and (11) Chemical Processing Equipment. The introduction discusses the Los Angeles Basin, rules and regulations in Los Angeles County, and the use of the manual. The appendixes' titles are: (A) Rules and Regulations; (B) Odor-Testing Techniques; (C) Hypothetical Available Heats from Natural Gas; and (D) Miscellaneous Data.

09789

Simon, Herbert

**SINGLE-STAGE ELECTRICAL PRECIPITATORS.** In: *Air Pollution Engineering Manual.* (Air Pollution Control District, County of Los Angeles.) John A. Danielson (comp. and ed.),

Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, PHS-Pub-999-AP-40, p. 135-156, 1967. GPO: 806-614-30

The history of electrostatic precipitation, its advantages and disadvantages, diverse applications, and mechanism are discussed. The mechanisms involved in electrical precipitation are treated in detail providing pertinent information on the following: construction; voltage for successful operation (rectifiers, effects of wave form, controlled sparking rate); uniform gas distribution; theoretical analysis of performance; theoretical efficiency; effects of resistivity; and effects of nonuniform gas velocity. Proportion, capacity, cleaning of electrical system, accessibility for maintenance, control of gas flow, control of erosion of dust from electrodes, and power supply are design factors that are critical elements in an electrostatic precipitator. The fundamental theory of the mechanisms involved in electrical precipitation is only partially understood at present. Designs are based either upon previous experience with similar processes or upon the results of pilot model precipitator studies. Data is tabulated on; dielectric constants for some common materials; pioneer precipitator installations (1907-1920); summary of U.S. precipitator installations in major fields of application; typical precipitator applications (flow rate, temperature, dust concentration, dust weight, efficiency, cost); suspended particulate matter in commercial gases in typical installations; average diameter of particles in various industrial operations; typical values of drift velocity encountered in practice for use with precipitators; and typical values for some design variables used in commercial electrostatic precipitator practices.

09823

MacKnight, Robert J. and John E. Williamson

**GENERAL-REFUSE INCINERATORS.** In: *Air Pollution Engineering Manual.* (Air Pollution Control District, County of Los Angeles.) John A. Danielson (comp. and ed.) Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, PHS-Pub-999-AP-40, p. 419-428, 1967. GPO: 806-614-30

The general refuse incinerator is used in residential, commercial, and industrial establishments is discussed with particular emphasis on the design of multiple-chamber incinerators for effective disposal of general refuse with a minimum creation of air pollution. Typical calculations involved in designing multiple chamber incinerators are illustrated. These calculations fall into three general categories: (1) Combustion calculations based upon the refuse composition, assumed air requirements, and estimated heat loss; (2) flow calculations based upon the properties of the products of combustion and assumed gas temperatures; and (3) dimensional calculations based upon simple mensuration and empirical sizing equations. The calculations needed to determine weights, velocities, and average temperatures of the products of combustion are derived from standard calculation procedures for combustion. Average gross heating values and theoretical air quantities are used. Chemical properties and combustion data for the major components of general refuse are given. General construction, refractories, grates and hearths, air inlets, stacks, induced draft system, and operation of a multiple-chamber incinerator are also included in the discussion.

09824

Netzley, Arthur B. and John E. Williamson

**MOBILE MULTIPLE-CHAMBER INCINERATORS.** In: *Air Pollution Engineering Manual.* (Air Pollution Control District, County of Los Angeles.) John A. Danielson (comp. and ed.),

Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, PHS-Pub-999-AP-40, p. 428-435, 1967. GPO: 806-614-30

Practical and economical answers that facilitate the design and construction of successful mobile multiple-chamber incinerators are discussed. Mobile incinerators are designed with parameters identical to those of multiple-chamber incinerators, however they must be constructed of lightweight materials and limited in size to comply with the State Vehicle Code. Design configurations generally restrict the maximum capacity of the retort style, to 500 pounds per hour, and that of the in-line style, 1,000 pounds per hour. Draft for mobile incinerators may be produced in two ways. The first and most conventional way is the use of a stack, while the other incorporates an induced-draft system that uses air to cool the effluent. Stack requirements and induced-draft fan system are described. Typical calculations involved in the design of an induced-draft fan system for a mobile multiple-chamber incinerator are illustrated. The mechanical design and construction of a mobile incinerator must not only meet the dimensional and weight requirements of the Vehicle Code but also provide a rigid frame and refractories of sufficient quality to provide a satisfactory service life. Refractories, grates, air inlets, structure, and auxiliary burners are discussed.

09826

Sableski, Joseph J. and John E. Williamson

**FLUE-FED APARTMENT INCINERATORS.** In: Air Pollution Engineering Manual. (Air Pollution Control District, County of Los Angeles.) John A. Danielson (comp. and ed.), Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, PHS-Pub-999-AP-40, p. 447-460, 1967. GPO: 806-614-30

There are three basic methods of altering a flue fed incinerator to prevent discharge of air contaminants. Two of these methods involve the addition of an afterburner to the existing incinerator, namely, a roof afterburner or a basement afterburner. The third method involves the installation of a well designed multiple chamber incinerator. These three methods are discussed providing information on design procedures, standards for construction, stack emissions and operation. Typical installations are shown schematically. The advantages and disadvantages of each method are indicated. Calculations involved in designing a barometric damper incinerator are illustrated.

10009

Fife, James A.

**CONTROLLED COMBUSTION FOR SOLID WASTES DISPOSAL.** Heating, Piping, Air Conditioning, 40(3):140-147, March 1968.

The basic design and operating characteristics of several types of large batch and continuous solid waste incinerators are discussed. Methods of particulate and odor emission control are considered with emphasis on the effects of firing and handling methods on emission rate. Economics of incinerator operation are presented. Water-wall steam producing incinerators are compared with refractory incinerators.

10455

Waitkus, Joseph

**WASTE HEAT RECOVERY AND AIR POLLUTION CONTROL--HOW AND WHY.** Combustion, 39(12):18-26, June 1968. (Presented at the Southern Ti Section of the American Society of Mechanical Engineers, Elmira Heights, N. Y., Jan. 23, 1968.)

Thermal pollution is an air pollution problem because it effects weather patterns. Waste heat recovery by means of recuperative or regenerative heat exchange equipment is discussed. To fully handle the pollution from industrial sources, a combination of waste heat recovery and particulate collection equipment is proposed. A brief description is given of wet scrubbers, cyclones, filter baghouses, electrostatic precipitators, and direct flame incineration.

10694

Kurker, Charles

**ABATEMENT OF AIR POLLUTION THROUGH CONTROL OF SOLID WASTE DISPOSAL.** Preprint, Connecticut Dept. of Health, Environmental Health Services Div., 12p., 1968. 4 refs. (Presented at the 61st Annual Meeting of the Air Pollution Control Association, St. Paul, Minn., June 23-27, 1968, Paper 68-159.)

The sanitary landfill method of disposal and incineration combined with sanitary landfill are satisfactory methods of disposal which eliminate the health hazards normally related with poor disposal practices. Other methods of volume reduction and modifications of present methods are being investigated to further reduce the emissions of air pollutants and conserve the limited land areas available for refuse disposal.

11652T

H. Knoch

**AUTOMATIC CONTROL OF REFUSE INCINERATORS.** ((Automatische Steuerung von Mullverbrennungsanlagen.)) Translated from German. Brennstoff-Waerme-Kraft. 16(8):402-403, Aug. 1964.

The devices (such as temperature controllers, control valves, air blowers, etc.) required for control guidance, and monitoring of plants for refuse incineration only and plants for refuse incineration with heat utilization are discussed and illustrated. In design work, consideration must be given to the fact that the plants are usually operated by relatively unskilled personnel, also that the very rough operation of the plant with much fly dust and acid effluents requires tough and corrosion-resistant devices. It is also important for the control system to be protected against interruption in operation by blockage. In the heat utilization design, the scheme of the units conforms to a great extent to that of a steam generating plant; auxiliary oil or gas firing may be used to provide extra steam during peak load periods.

11658T

Hans-Joachim Ochs

**THE USE OF AIR FILTERS IN REFUSE INCINERATION PLANTS.** ((Einsatz von Luftfiltern in Mullverbrennungsanlagen.)) Translated from German. Wasser Luft und Betrieb, 8(9):535-537, Sept. 1964.

A recirculating filter system equipped with a sludge-free fine-filter for collecting dust in a refuse incinerating plant in Hamburg, Germany is described and illustrated. Much dust invariably rises from refuse storage bins located underneath the furnaces and must be controlled. The air filter system used involves spraying a wetting material under pressure through the recirculation cells from the wetting material container from underneath the recirculating filter element that is normally used only for the wetting agent for contact rinsing. The wetting material, as it passes through the recirculating filter cells, loosens the accumulated dust deposited on the cells, becomes enriched with it, and forms a sludge precipitate at its bottom. This sludge, in turn, is discharged at the bottom of the wetting material container and passed to settling tanks whence it is



recirculated into the system after subsequent settling and filtration.

11792

Kaiser, Elmer R.

**REFUSE REDUCTION PROCESSES.** Public Health Service, Cincinnati, Ohio, National Center for Urban and Industrial Health, Proc. Surgeon General's Conf. Solid Waste Management Metropol. Washington, 1967, p. 93-103. 2 refs. (July 19-20).

The following processes are considered with respect to weight and volume reduction of refuse containing organic combustible matter and an important fraction of noncombustibles: open burning at dump sites; burning in conical metal chambers; landfilling; composting, with sale of compost; incineration without heat recovery; and incineration with heat recovery. Volume reduction is impressive when incinerated residue is landfilled. After depositing, the residue from an original ton of refuse occupies no more than 0.194 cu yd. Attention is also called to the demonstrated possibility of oxidizing and melting incinerator residue and to the use of electrostatic precipitators, gas scrubbers, and bag filters to meet new dust emission standards. The advanced state of European incinerator art is reviewed. The new-type refuse reduction plants discussed consists of refuse receiving pits, cranes with grapples to elevate the refuse to hoppers, stoker-fired boilers, precipitators, and chimneys 260-390 ft high. Because of the water-tubed furnaces, the refuse can be burned with 1.6 times the stoichiometric air, instead of three times as in U. S. practice; the weight and volume of flue gas to be cleaned is reduced considerably. The cooling of the gases to 500-600 F in the boiler-superheated-economizer contracts the gas volume without the addition of spray water. The generated steam is used for the production of electric power and for district heating, in conjunction with the local electric utility. Because it is lower in moisture and ash, U. S. refuse should generate more steam per ton than European refuse.

12080

Anon.

**FLUID BED INCINERATORS STUDIED FOR SOLID WASTE DISPOSAL.** Environ. Sci. Technol., 2(7):495-497, July 1968.

The versatility of fluid bed waste incinerators means that cities can use them to dispose of sewage sludge, refuse, solid industrial wastes, and liquid and gaseous wastes. Under an HEW demonstration grant, a research group at West Virginia University hopes to demonstrate the feasibility of continuous combustion of a large variety of materials in fluid beds. The problems encountered and the system requirements are discussed. Pope, Evans & Robbins envisions a fluid bed incinerator, capable of burning up to 1000 tons of refuse per day, that could be factory assembled and loaded on a rail car for shipment. Combustion intensity would be more than five times as great as in a conventional unit of equivalent capacity.

12651

Anon.

**AIR POLLUTION CONTROL EQUIPMENT BUYERS' GUIDE.** Air Eng., 10(12):27-42, Dec. 1968.

This buyers' guide for air pollution control equipment gives a listing by category and product and an alphabetical listing of manufacturers with complete name and address of the supplier.

12655

**PRODUCT GUIDE 1969. DIRECTORY OF AIR POLLUTION PRODUCTS LISTS MANUFACTURERS OF EMISSION CONTROL EQUIPMENT AND AIR POLLUTION INSTRUMENTATION.** J. Air Pollution Control Assoc., 18(12): 847-857, Dec. 1968.

This directory of air pollution products lists manufacturers under product classifications within the two major categories of emission control equipment and air pollution instrumentation. In addition the guide contains an alphabetical listing of manufacturers with mailing addresses.

12664

H. J. Campbell, Jr., A. L. Friedland

**INCINERATORS AND THE PUBLIC.** Mech. Eng., 90(12):38-43, Dec. 1968.

Master planning for community incinerator design involves consideration of the site from the point of view of convenience when erected, likely shifts in population density, availability of nearby areas requiring landfill, and projected other social uses of the site 20 to 30 years later. Multiple incinerator units seem to offer an insured actual continuous burning capacity, even in the event of operational failure of one unit, so that refuse accumulation can be avoided. Economic, aesthetic, and community considerations are all discussed.

13133

Dvirka, Miro

**INCINERATOR AND FLY ASH SEPARATOR STRUCTURE THEREFOR.** (Hagan Industries, Inc., Corona, N. Y.) U. S. Pat. 3,448,704. 5p., June 10, 1969. 6 refs. (Appl. July 8, 1966, 13 claims).

An incinerator having a combustion chamber, a flue, and a structure for separating fly ash or solid particles from combustion gases emanating from the combustion chamber is described. The dust collection system is made up of a settling chamber, an inlet passage connected to the combustion chamber, and an outlet passage connected to the flue. The inlet and outlet passages are situated in such a way that the combustion gases passing through the settling chamber describe a curved path about a center of curvature located between the passages. The intake of the outlet passage is located close enough to the center of curvature that the fly ash migrates along involute paths under the influence of centrifugal forces resulting from the motion of the combustion gases. The ash impinges on a wall of the settling chamber and is trapped. The cleaned air then passes out through the flue. A relief passage connecting the settling chamber to the flue should have a cross-sectional area of not more than 5% of the flue area. The cross-sectional areas of the inlet and outlet passages should be equal.

13363

Taylor, Herbert E. and David R. Pearl

**INCINERATOR DRAFT CONTROL AND VENT VALVE.** (Combustion Engineering Inc. Windsor, Conn.) U. S. Pat. 3,447,493. 4p., June 3, 1969. 3 refs. (Appl. Dec. 28, 1967, 2 claims).

A combined incinerator and wet scrubber are discussed. The hot, dust-laden gases from the incinerator are scrubbed and cleaned in the scrubber and flow through a space enclosed by a double wall arrangement of the incinerator. A damper valve, positioned in the duct between the incinerator and the wet

scrubber, maintains the incinerator at a predetermined partial vacuum during normal operations. This enables the refuse to be burned without smoke escaping from the furnace doors, joints, or seams. The valve also closes the duct when a maximum temperature is reached downstream from the wet scrubber. This prevents any hot gases from the furnace from entering the scrubber. Cold atmospheric air flows through the scrubber and the double walls of the furnace, thus preventing any overheating or damage. (Author abstract modified)

13697

Obering, E. Albrecht

**SLUDGE INCINERATION IN THE FLUIDIZED BED FURNACE.** (Schlammverbrennung im Wirbelschichtofen). Text in German. Chem. Ing. Tech., 41(10):615-619, 1969. 2 refs.

Sewage sludge disposal becomes an ever greater problem since dump sites are becoming scarce and awareness of the danger of uncontrolled dumping is spreading. Disposal by incineration decreases the volume and leaves sterile ash and inert odorless gases. Sludge incineration must be preceded by mechanical dehydration to avoid emission of volatile organic sludge components with the waste gas and to permit autonomous combustion. To achieve the latter goal, the combustion temperature must be high, the excess air in the reaction chamber low, the incineration complete, and the temperatures of the waste gases and vapors low. However, the waste gas temperature may not drop below 750 C if odors are to be avoided and if the residues ought to be sterile. To solve the problem, the fluidized bed furnace must be used. The sludge falls into a bed of turbulent sand particles where it is dried, degassed, and ignited. The temperature of the waste gas at the combustion chamber outlet is 800 to 900 C. It is cooled in an air preheater and the heat is returned to the combustion chamber. In the subsequent dust collector, the mineral sludge components are separated as dust either by a wet or dry process and tapped off to an ash pit. The turbulent sand particles are slowly eroded and carried off with the ash. They are replaced by larger ash particles and by sand brought in by the sewage sludge. The furnace has no movable parts aside from the charging facility and the ventilators so that wear and tear are low. The city of Lausanne has operated such a fluidized bed furnace since 1965. The furnace burns 2600 kg of dehydrated sludge per hour (max. water content 60%). Part of the waste gas is used to heat the combustion air and the rest goes to a boiler. The waste gases are cleaned in cyclone separators and electrostatic precipitators.

14061

Velzy, C. O.

**THE ENIGMA OF INCINERATOR DESIGN.** New York, American Society of Mechanical Engineers, New York, 1968, 8p. 17 refs. (Presented at the ASME Winter Annual Meeting and Energy Systems Exposition, New York, Dec. 1-5, 1968.)

Until recently, municipal incinerators were largely empirically designed. The increasing emphasis on prevention of pollution of the environment, together with rapidly changing refuse constituents and characteristics, is forcing a change in these previously accepted design approaches. To select the air pollution control equipment best suited to a particular problem, concise information as to the nature, characteristics, and magnitude of the problem is required. The more rigid present day air pollution codes will require the application of more sophisticated abatement equipment. Such equipment includes medium-to high-energy wet scrubbers and electrostatic precipitators. With refractory furnaces, the gases must be cooled prior to being discharged to the air pollution control equipment. This is ac-

complished by adding spray water to the gas stream. A portion of the gaseous pollutants discharged from the furnace would be removed by this cooling water. Much more data must be collected from presently operating incinerators and properly correlated with furnace type, furnace configuration, operating variables, and refuse composition.

14364

Matsumoto, K., R. Asukata, and T. Kawashima

**THE PRACTICE OF REFUSE INCINERATION IN JAPAN BURNING OF REFUSE WITH HIGH MOISTURE CONTENT AND LOW CALORIFIC VALUE.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 180-197. (May 5-8).

The history and development of Japanese refuse incineration facilities are presented. Numerous studies were conducted on analysis of refuse, problems of public hazards and nuisances, and theories on drying and combustion, which resulted in the formation of a Standard for Incineration Facilities in 1966. These standards have provided a stringent policy guidance for incinerator construction, as well as effective guidance to manufacturers of incinerator equipment. In 1967, a 5-year plan was undertaken to improve sanitation facilities. Processing capacity at the end of 1966 was estimated to be 27,685 tons/day. It was estimated that an additional amount to be processed during and after 1967 amounted to 33,965 tons/day. The number of cities, towns, and villages requiring refuse incineration facilities was 1273 at the beginning of the 5-year plan. Refuse in Japan has a far higher moisture content and lower calorific value (lower heating value: 500 to 1300 kcal/kg, 40 to 70% moisture content) than that of Europe or America (lower heating value: 1000-2500 kcal/kg, 10 to 45% moisture content). In the design and production of high-quality incinerators which will completely burn refuse with a high moisture content and low calorific value, the following essentials must be considered: (1) Means should be provided for effective drying of refuse; (2) the amount of fuel consumed to assist in combustion should be held to a minimum; and (3) the combustion rate should be maximized. In Japanese incinerators, refuse is dried, either by gas or air, and burned on a stoker, and the performance of this mechanism has a direct bearing upon that of the incinerator. Various types of reciprocating and traveling grate stokers are described. A typical incinerating process is detailed, together with a flow diagram of a mechanical incinerator such as is used in Japan.

14365

Fernandes, J. H.

**INCINERATOR AIR POLLUTION CONTROL.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 101-116. 44 refs. (May 5-8).

Although an incinerator stack may appear reasonably clean, the fly ash in the gas may be excessive. Large quantities of air used in incineration often mask the real pollution potential. As a result, stack observations are no measure of emission from an incinerator. An accurate determination of stack emissions can be obtained only by actual test based on samples taken in the duct leaving the air pollution control equipment. This paper presents a survey of the performance capability of air pollution control equipment. It is clear that more knowledge of incinerator pollutants is required, and some research must be performed if all classes of high-performance air pollution control equipment are to be applied to incinerators with optimum results. Regardless of whether lax or stringent air pollution



regulations are in effect, collectors of good design, properly installed, operated, and maintained, can be selected. The relative cost of the various classes of equipment is presented. (Author summary modified)

14369

Eberhardt, H. and W. Mayer

**EXPERIENCES WITH REFUSE INCINERATORS IN EUROPE, PREVENTION OF AIR AND WATER POLLUTION, OPERATION OF REFUSE INCINERATION PLANTS COMBINED WITH STEAM BOILERS, DESIGN AND PLANNING.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 73-86. 7 refs. (May 5-8).

European steam generators with refuse firing must meet a number of stringent legal requirements for environmental control. In Germany, the dust emission of refuse incineration plants with a refuse throughput of more than 20 tons refuse/day may not exceed 150 mg dust/cu Nm clean gas referred to 7% CO<sub>2</sub> at any time. Depending on the preload of the site environment, this value must still be lowered so as to remain within the emission limits of 0.42 g/sq m/day for the annual mean and 0.65 g/sq m/day for the monthly mean. Flue dust collectors have over 98% efficiency. Difficult physical and chemical problems with the fuel and with boiler availability are met by attention to many engineering details. While the analysis of residential refuse is a relatively simple procedure, the determination of the volume and composition of industrial refuse is especially difficult and contributes in large part to the difficulties in planning and design of incineration plants. In Europe, refuse incinerators are combined with steam boilers, and operation of these large plants has shown that boilers with refuse fire chambers including the accessory equipment differ fundamentally from conventional plants in design and operation. The paper considers these plants in detail and compares them with plants operating with fossil fuels. It is shown that corrosion of boiler and superheater tubes is largely prevented by maintaining oxidizing conditions in critical areas. It was concluded that the primary factor in all considerations of the special requirements for refuse incineration plants, compared to conventional steam boilers, is the conversion of wastes into sterile end products.

14522

Woodruff, P. H. and G. P. Larson

**COMBUSTION PROFILE OF A GRATE-ROTARY KILN INCINERATOR.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 327-336. (May 5-8).

Tests were conducted on a 300 t/per day grate-rotary kiln incinerator to establish criteria for design modifications and to determine operational procedures necessary to comply with air pollution regulations and to reduce nuisance complaints. Samples of oxygen, carbon monoxide, and carbon dioxide were collected at the end of the rotary kiln, in the secondary combustion chamber, the area in front of the water sprays, and in the stack. Temperatures and velocities of the gas stream, plus particulate loading to the incinerator, were also determined. Organic constituents found in the secondary combustion chamber indicate that combustion is not always complete before the gas stream reaches the water sprays. Air under grates promotes suspension of excessive amounts of particulates in the gas stream, while outside air drawn into the ash pit produces turbulent conditions preventing deposition of lighter ash particles in the pit. In addition, the startup period is excessive. Proposals are made for operating the incinerator on a

seven-day basis, installing burners in the primary and secondary burning zones, reducing infiltrated air, and installing baffles across the secondary combustion chamber.

14524

Stabenow, G.

**PERFORMANCE AND DESIGN DATA FOR LARGE EUROPEAN REFUSE INCINERATORS WITH HEAT RECOVERY.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 278-286. 8 refs. (May 5-8).

In Europe, where the demand for better air pollution control and shortage of landfill areas became acute at an earlier stage, efficient incinerator design is more advanced than in the United States. Now that the solid waste disposal problem requires immediate attention in this country also, a study of European design data is in order. Considering that European furnaces have been successfully subjected to all types of refuse, including industrial waste with exceedingly high heating values and refuse with high moisture and ash contents, there is reason to believe that similar equipment will perform equally well in the United States. The apparent trend in Europe is toward large municipal incinerator stations where raw refuse is fed to combustion chambers with a guaranteed burnout rate. Furnace walls are cooled with water and available heat is recovered and utilized for power or heat generation. The residue consisting of ashes and other nonburnable materials occupies only 6% of the original volume of refuse fed to the furnace. Design improvements that have taken place in the past few years are reflected in the design specification presented in this article. These specifications should help municipal authorities and consulting engineers select a design that will do better than barely meet new standards for soil, air, and water pollution.

14612

Zinn, Robert E. and Walter R. Niessen

**COMMERCIAL INCINERATOR DESIGN CRITERIA.** American Society of Mechanical Engineers New York Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 337-347. 1 ref. (May 5-8).

Increasing collection and disposal unit rates, compounded by increasing refuse generating rates, are leading many industries, shopping centers, and the like to attempt disposal of their own solid wastes. In many cases, resulting savings, together with the elimination of unhealthy accumulation of wastes, are sufficient to justify private disposal systems. However, upgrading the capabilities of these incinerators is necessary in view of projected increases in the use of plastics, metal foils, and glass as packing materials. These materials can cause failure of incinerator grates, supporting structures, and operating mechanisms. Combustion air control with suitable agitation of the residue to attain good burnout is shown to be a necessary design parameter. Thus, future designs of incinerators must avoid the use of grate systems, yet provide adequate stoking of the burning mass to obtain complete oxidation. Provisions should also be made to install burners in both primary and secondary chambers and to achieve a continuous flow of refuse and ash. If refuse is moved through the system in a plug flow manner, hot combustion products from freshly charged materials can be used to assure burnout of the ash.

14613

Rohr, F. W.

**SUPPRESSION OF THE STEAM PLUME FROM INCINERATOR STACKS.** American Society of Mechanical Engineers New York Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 216-224. 2 refs. (May 5-8).

The use of water scrubber systems for municipal, commercial, and industrial incinerators results in the generation of a super-saturated water vapor which leaves the stack in the form of a visible white plume. The plume reveals the presence of an incinerator which may be capable of inoffensive operation in an urban area, but its continuously identifiable presence can become a standard by which property value is graded. Various methods are possible for the reduction of the moisture content of gases, and therefore, suppression of the steam plume. These methods are: (1) electrostatic precipitation of water droplets from fogged air; (2) mechanical separation of water droplets from fogged air; (3) absorption or adsorption of water vapor; (4) mixing of the moist gases with relatively dry heated air; (5) condensation of the moisture by direct contact with water or on cold surfaces; and (6) reheat of scrubber exhaust gases. An evaluation of systems utilizing these methods indicates that cost of scrubber systems with the means for suppression is related to the lowest ambient air temperatures at which the system is designed to be effective and to the method of dehydration of the flue gases. This preliminary analysis has indicated that the costs of these systems for use at temperatures above 20 F may be comparable to wet scrubber systems in which no provision is made for suppression.

14736

Rathgeber, Ferdinand

**DUST REMOVAL FROM WASTE GASES FROM REFUSE INCINERATION.** (Entstaubung der Abgase aus der Verbrennung von Abfall und Muell). Text in German. Wasser Luft Betrieb, 13(2):46-50, Feb. 1969. 2 refs.

The two means suitable for cleaning waste gases from refuse incinerators are cyclones and electrostatic precipitators. They must be preceded by some type of waste gas cooling system. For smaller incinerators, fresh air is primarily used for this purpose, while in medium size and large incinerators, the selection is wider. Here, the waste gases can be cooled with cold air, water, or by utilizing the waste heat. Due to stringent laws concerning the control of emissions, cyclones can be used only for smaller incinerators. Electrostatic precipitators with their high collection efficiencies are suitable for installation in any kind of incinerator. Small, compact electrostatic precipitators are available and help save on installation costs. Should it be necessary, mechanical filters can be installed behind electrostatic precipitators to retain charred paper flakes.

14940

Tada, Mitsuru

**INDUSTRIAL WASTE INCINERATION BY FLUIDIZING SYSTEM.** (Sangyo haikibutsu no ryudoshokyakuho). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 5(7):529-533, July 1969.

Fluidizing systems, which are widely applied to petroleum and mineral combustion, are highly efficient. The outstanding merits of this system are a capacity of 500 kg/cu m-hr incineration; the ability to incinerate low-calorie wastes (1000/kcal/kg, water 70%) without catalysts; perfect combustion with kiln heat around 750 C; no stack smoke or odor problems; simplicity of structure, with no vibrations inside the kiln and

constant and stable internal heat; availability of electric power, produced though the process in large-scale (400 t/day) kilns of this system; convenient operation requiring no heavy or intensive labor; and economical maintenance. The system has a wide range of applications, including waste incineration in the chemical, food processing, and petroleum industries, and excrement and sludge treatment. For example, the liquid wastes from paper manufacturing plants that used to be discharged into rivers, bays, or seas and caused problems for agriculture, fishing, and shipping may now be incinerated, removing all the organic matter contained in pulp wastes, and chemical compounds such as Na<sub>2</sub>SO<sub>4</sub> or Na<sub>2</sub>CO<sub>3</sub> may be recovered and reused in kraft pulp production. Adaptation of this system to watery wastes in the food and chemical industries has the advantages of deodorizing wastes and recovering ash for use as fertilizer. The system can be adapted to petroleum and petrochemical wastes and to high-temperature wastes.

14967

Hein, G. M. and R. B. Engdahl

**A STUDY OF EFFLUENTS FROM DOMESTIC GAS-FIRED INCINERATORS.** (American Gas Association, Inc., New York, Proj. DG-3M, 27p., June 1959. 24 refs.

Measurements were made of the effluents from nine domestic gas-fired incinerators, including two new prototype models, five new commercial units, and two older units. Standard test charges that typified wet domestic wastes and dry combustible materials, and two special refuse mixtures were burned. A free-standing chimney provided natural draft for the units. Sampling and analytical techniques were based on recognized methods. The concentrations in ppm in the flue gas and the emission rates in pounds per ton of refuse burned were determined for aldehydes, nitrogen oxides, organic acids, ammonia, and hydrocarbons. Grain loadings and emission rates were determined for particulate matter which included tarry organic materials. Odor and smoke density were also determined. Results demonstrated that significant reduction in emissions has been achieved through recent improvements in incinerator design. When wet domestic wastes are incinerated in new units, of up to 6-fold decreases in the rate of aldehyde emissions are achieved. Decrease in organic acids is 3-fold; decrease in saturated hydrocarbons is 8-fold. Although nitrogen oxides have increased 3-fold because of increased gas in the afterburner, their concentration is still lower compared to other combustion sources. Smoke, odor, and particulate matter emissions decreased to acceptable levels. Comparison of these emission rates with those from municipal incinerators shows that the new improved gas-fired domestic incinerators have lower particulate emissions, and, in general, equally low emissions of gaseous pollutants. Emissions from improved gas-fired units were in most cases lower than those from other incinerators and large gas and oil-fired industrial heating units; they were much lower than those from automobile exhaust. The results of the study provide a basis for modification of the present restrictions in certain areas on the use of gas-fired domestic incinerators and for confirmation of their present acceptance in other areas.

15201

Clark, William T.

**DESIGN OF A LARGE MUNICIPAL INCINERATOR.** Preprint, Air Pollution Control Assoc., South Atlantic Section, 11p., Nov. 19, 1969.

Design specifications for a municipal incinerator in the District of Columbia were derived from studies of the effects of such furnace variables as temperature, excess air, fuel bed agita-



tion, and incomplete combustion in the generation of contaminants. To achieve necessary control of incinerator operations, a new furnace configuration was developed. This configuration is directed toward obtaining uniform gas velocity patterns, uniform temperatures, longer gas retention time, and less entrainment of particulates in the flue gas stream. A combination of cyclones and electrostatic precipitators was chosen to control flue gas temperature and avoid condensation corrosion. By collecting large fatty acids, the cyclones will reduce fouling of the precipitator's collector plates. Specifications call for a minimum 95% precipitator efficiency. The plant will process 1500 tons of refuse per 24 hrs. It contains shredding equipment for large bulky refuse, metal separation equipment on the shredder discharge, and laboratory facilities for testing different facets of solid waste disposal. One of the six furnaces is fully instrumented to obtain air flow and flue gas data and to measure furnace temperatures. Particulate and gaseous incinerator flue gas constituents are tabulated.

15396

Naito, Jun and Satoru Fujii

**AN INCINERATOR.** (Shokyakuro). Text in Japanese. (Assignee not given.) Japanese Pat. Sho 44-11707. 2p., May 28, 1969. (Appl. March 24, 1966, 1 claim).

The chimney of this incinerator consists of two concentric cylinders and is provided with a cover at the top. The cover has several holes through which a part of the smoke escapes to the atmosphere. The rest of the smoke is mixed with air through the hole and flows down the inner cylinder. This induces more fresh air to be brought in through the hole. The gas is heated up while flowing down along the inner cylinder which is heated up by the up-flowing hot smoke. The gas is led to the combustion chamber to dilute the smoke and make the combustion more complete.

15544

Hangebrauck, Robert P. and George D. Kittredge

**THE ROLE OF COMBUSTION RESEARCH IN AIR POLLUTION CONTROL.** Preprint, Public Health Service, Cincinnati, Ohio, National Air Pollution Control Administration, 17p., Sept. 1969. 10 refs. (Presented at the Combustion Institute, Eastern States Section, Technical Meeting, Morgantown, W. Va., 1969.)

Research and development projects aimed at developing technology for minimizing emissions from combustion processes are reviewed. The projects are discussed in relation to specific pollutants and sources, which include electric power production, industrial and residential combustion, refuse combustion, and motor vehicle sources. For stationary sources of pollution, fluid bed combustion may provide an economical system of heat generation for reducing emissions of sulfur oxides, and perhaps nitrogen oxides, from fossil-fuel combustion by steam-electric power stations. Research is in progress on models for predicting nitrogen fixation; these models would be used in design of burners and boilers for low output of NO<sub>x</sub>. Another possibility for controlling power generating systems involves integrating new power cycles with fuel cleaning. Improved burner and furnace designs offer opportunities for reducing pollution from sources other than power generators. Current development work in incineration could lead to both lower pollution levels and better use of resources by heat recovery. For motor vehicle sources of pollution, the possibilities of control are diverse. Industry is concentrating chiefly on enhancing combustion in spark-ignition engines by improving fuel atomization, air-fuel mixing, and distribution. Also under study are changes in fuel composition,

high-temperature exhaust system reactors, and exhaust gas recirculation for NO<sub>x</sub> control. Elsewhere, alternative types of low-emission propulsion system, in particular Rankine cycle systems, are under development. Control techniques for diesel engines are directed toward improving fuels and engine designs to eliminate smoke and odor. Finally, projects for reducing emissions from aircraft are underway.

16137

Hishida, Kazuo

**SMOKE PROPERTIES OF REFUSE INCINERATORS AND DUST COLLECTORS FOR THE INCINERATORS.** (Gomi shohkyaku ni tomonau haigasu to sono jojin ni suite). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 4(10):637-645, Oct. 15, 1968. 4 refs.

Smoke from refuse incinerators is not only a cause of air pollution but a source of complaints from local residents. In Tokyo in 1967, there were 92 cases involving complaints about incinerator smoke; these constituted 12% of the total complaints concerning smoke. Refuse incineration is divided in two classes: batch combustion methods and continuous combustion methods. In batch (fixed furnace) operations, refuse is burned intermittently; the working environment in the furnace is bad. The method should be replaced by that of continuous combustion. There are also two classes of refuse: garbage and miscellaneous refuse. A mixture of the two is called a mixed refuse. Since they contain large amounts of water, garbage or mixed refuse are difficult to burn. The main components of the gas produced by refuse incineration are hydrogen chloride, sulfur oxides, ammonia, aldehydes, organic acids, and nitrogen oxides. Their concentrations can reach 2000 ppm but, with the exception of organic acids and nitrogen oxides, can be controlled to below 500 ppm. Concentrations of organic acids and nitrogen oxides do not decrease at high combustion temperatures. A solution for this problem must be found. More dust is released by batch than by continuous combustion of refuse, and sulfuric acid is its predominant component. Because of the complex nature of incinerator refuse dust, the use of dust collectors is advocated. A dry electric collector, used alone or in combination with a centrifugal collector, is recommended.

16536

Kurosawa, Keiji

**ENRICHED AIR COMBUSTION OF HARD-TO-BURN REFUSE.** (Toshi jinkai shokyaku ni taisuru sanso riyō ni tsuiteno ichi kosatsu). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 2(11):771-773, Dec. 1966. 1 ref.

Enriched air combustion of refuse has advantage, though investment costs are high. Oxygen lowers the ignition temperature. Nitrogen decreases combustion smoke with no loss of heat. The higher the flame temperature, the less the odor of combustion smoke. Reduced smoke makes it easy to remove smoke dust. Wet and watery refuse can be burnt with savings in heavy oil. The combustion smoke remaining inside the incinerator burns more refuse in the same incinerator in an equivalent period of time than other combustion methods. The oxygen content of air is only 21%, the remaining 79% consisting of nitrogen and argon. A large proportion of combustion heat in the air is used to heat the nitrogen. Since refuse in Japan is generally more watery than that in western countries, more heavy oil is needed as a subsidiary fuel. Oxygen application reduces the heavy oil consumption for refuse incineration. Present equipment for separating oxygen from air by liquefaction reflects great technological progress. A 10,000 cu Nm/h capacity can be found in some iron and steel works, or petroleum industry plants. Construction expenses are esti-

## B. CONTROL METHODS

47

mated to be approximately 80 to 90 billion for 95% O<sub>2</sub> at 10,000 cu Nm/h.

16730

Sebastian, F. P., A. F. Arie, and B. B. Garretson

**MODERN REFUSE INCINERATION.** *Mech. Eng.*, 91(4):27-32, April 1969.

A new generation of refuse incinerators has made West Germany the leader in the technology of solid waste disposal. A plant constructed at Dusseldorf to serve a 61.1 sq. mi metropolitan area with a population of over 698,000 has been designed to operate on unsegregated municipal refuse with an average calorific content of 2600 Btu/lb. In addition to reclaiming heat energy in the form of steam from the refuse, the burned-out residue is processed to recover ferrous metals and usable inert materials. The German air pollution code requirements are met through the use of electrostatic precipitators and a 100 m stack. Flue gases are carefully monitored. The Dusseldorf plant will have six incinerator/boiler units when completed. Total revenue will be about \$3.40/tn of refuse, an amount which would suffice to meet all operating costs and allow for amortization of capital costs.

16749

Rolfe, T. J. K.

**REFUSE INCINERATION.** *B.C.U.R.A. (Brit Coal Util. Res. Assoc.) Gaz.*, 33(2):28-31, Feb. 1969. 12 refs.

Incinerable wastes cover a wide spectrum of gaseous, liquid, and solid materials. The problems posed by the need to dispose of increasing quantities of refuse by incineration have been discussed in a number of papers. This is a review of the incineration problem particularly as it relates to house refuse.

16751

Pottinger, J. F.

**NEW STANDARDS FOR INCINERATORS IN NEW SOUTH WALES.** *Clean Air (J. Clean Air Soc. Australia New Zealand)*, 3(1):29-36, March 1969. 6 refs.

The New South Wales Department of Public Health set up an Incinerator Committee two years ago to investigate incinerator practices and to set standards of design aimed at minimizing emissions to the atmosphere. The standards which are presented in full in the article apply to domestic (except single family dwellings), commercial, and industrial incinerators. The incinerator standards are based on up-to-date information on incinerator design and practice. In the standards various types of waste material handled by incinerators have been divided into five groups. Multiple chamber design is recommended for incinerators to promote the complete combustion of all solid and gaseous combustibles. Five classes of incinerators have been defined with specifications given for each class.

17275

LaRue, Phillip G.

**POLLUTION-CONTROLLED GAS INCINERATION: A SOLUTION TO THE GROWING PROBLEM OF SOLID WASTE DISPOSAL.** *ASHRAE (Am. Soc. Heating, Refrig. Air-cond. Engrs. J.)*, 12(2):58-62, Feb. 1970. 4 refs.

Incineration of solid waste can be most effectively accomplished in a gas-fired multiple chamber incinerator. The incinerator is built to design criteria which allow adequate combustion chamber area, grate area, grate-to-burner design, and a method for remixing the off gases (from the primary combustion chamber) with additional air supply. The mixture is

passed through a zone of flame at 1200 F or higher where secondary combustion takes place. In the secondary chamber, the time, temperature, and turbulence of combustion are utilized to complete the combustion of the off gases. The initial temperature and flame length necessary to reburn smoke, odor, and fly ash are created by an afterburner. A modern gas incinerator should be capable of passing the most stringent incinerator codes now in effect. On larger commercial industrial units, a gas washer or electrostatic precipitator may be necessary. In a gas washer, the gases and fly ash are trapped and passed through the unit where they are mixed with water to trap and settle out the particulate matter from the gas stream. With such a device, emissions are controlled to a point well below most acceptable limits.

17403

Hashimoto, Kiyotaka

**THE POINT OF PLANNING AND ITS EFFECT ON OPERATION RESULT OF AN ELECTRIC PRECIPITATOR IN VARIOUS INDUSTRY SMOKE ABATEMENT (IX) - TREATMENT OF EXHAUST GAS FROM REFUSE INCINERATOR.** (*Gyohshubetsu ni miru denkishuhjin sohchi no setsubikeikaku to untenkohka (IX) - Jinkai shohkyaku no tomonau haigasu shori ndao*). Text in Japanese. *Kogai to Taisaku (J. Pollution Control)*, 3(9):543-548, Sept. 15, 1967. 11 refs.

Urban refuse includes many inorganic containers and vinyl bags that present difficulties with respect to perfect combustion. In Japan, the choice of incineration by equipment and incinerating schedules is left to each municipality independently; an 8 hr/day operation is common. In such cases, imperfect combustion interferes with the performance of dust collectors when they start or stop operations, and odorous waste gas emissions are unavoidable. Corrosion of the installations and damage by the heat-cycle are increased by Cl<sub>2</sub>, NH<sub>3</sub>, SO<sub>2</sub>, SO<sub>3</sub>, etc.. Consequently, a 24 hr/day operation plan with standardized equipment is advisable. For adequate combustion, O<sub>2</sub>-rich air should be used. Most recently constructed incinerators employ the following types of treatment: flow rate is controlled by a continuous dust-feeding method; dry waste gas is resolved and the odor removed through high-temperature combustion area in incinerators; temperature of the combustion waste gas is controlled, and dust removed by dry methods. Because of the wide variety of refuse in Japan, little progress has been made in standardizing incinerator operations. It is necessary to set up pretreatment installations and to improve dust removal installations.

18252

Andersen, Lester Hans

**INCINERATOR HAVING IMPROVED SCRUBBER.** (Clear Air Waste Reduction Corp.) U. S. Pat. 3,447,287. 17p., June 3, 1969. 8 refs. (Appl. Dec. 18, 1967, 19 claims.)

The specification discloses a scrubber and dryer apparatus particularly useful in conjunction with municipal incinerators for the removal of fly ash from gaseous combustion products. The scrubber comprises a chamber having surface-porous castable refractory piers in several staggered rows. In one embodiment, the chamber widens from front to rear and the spacing between adjacent piers in each succeeding row decreases. The ash is trapped by impingement on a continuous curtain of water disposed at the inlet of the scrubber just upstream of the piers. Water to form the curtain is pumped into a manifold set transverse to the chamber inlet in which there is a slot. The gases carry the water downstream in relatively large droplets to impinge on the piers where the water and trapped ash flows off. The dryer chamber comprises a deflect-



ing arch with openings that direct the gases against the chamber walls and strips the water from them. The gases, after passing through the scrubber and then the dryer, are exhausted as substantially clear air, having a tested dust loading value of 54 to 68% below the commonly accepted standard of 0.85 lb dust/1000 lbs flue gas. In addition, the scrubber and dryer can be used for trapping SO<sub>2</sub> in the production of sulfuric acid. (Author abstract modified)

19236

Samples, Randall H. and Roddy K. Street

**APPARATUS FOR PURIFYING AND ACCELERATING THE FLOW OF EFFLUENT GASES IN A GASEOUS FLOW STREAM.** (Commercial Fabrication and Machine Co., Inc., Mount Airy, N. C.) U. S. Pat. 3,504,894. 4p., April 7, 1970. 12 refs. (Appl. Feb. 21, 1968, 10 claims).

The improved incinerator described is provided with means for accelerating the flow of effluent gases and also with means for cooling the incinerator during combustion. The lower portion of the combustion chamber includes a vertical cylindrical wall and the upper portion, a frusto-conical wall which is attached to the cylindrical wall and which converges upwardly to a hood with a gaseous outlet opening. The outlet communicates with a conduit through which the gaseous effluent flows and where it is cooled by sprays of pressurized water. The pressurized liquid is directed downward through venturi-shape rings to accelerate the flow of oxidizable gases passing into inlet openings in the lower portion of the incinerator and through the combustion chamber, thereby facilitating combustion. Both the cooling water and the contaminant-laden liquid fall onto the babbled outer surface of the frusto-conical wall from which the combined liquids fall by gravity down the walls of the incinerator to effectively cool it during combustion.

19550

Ellsworth, R. D. and R. B. Engdahl

**THE CONTROL OF EFFLUENTS FROM MUNICIPAL INCINERATORS.** J. Air Pollution Control Assoc., 7(1):43-46, May 1957. 9 refs. (Presented at the Air Pollution Control Association, East Central Section Meeting, Columbus, Ohio, Sept. 1957.)

For various reasons, it is apparent that incineration of rubbish is going to be the primary method of disposal in the future. Incinerator technology and emission problems are discussed. Various types of flue gas sampling mechanisms are described. Tabulated results of emissions from municipal incinerators are given. The settling-chamber type of collection system usually incorporated into the design of larger incinerators either needs improvement or additional collection equipment must be added. Fly-ash emissions can be controlled by wet scrubbers, but high cost and water problems can occur. Inertial separators employing baffles may be used to control particulates. Full-scale tests on existing installations are needed to supply necessary information.

19597

Stephenson, Junius W.

**INCINERATION - PAST, PRESENT, AND FUTURE.** Preprint, American Society of Mechanical Engineers, New York, 20p., 1969. 49 refs. (Presented at the American Society of Mechanical Engineers Winter Annual Meeting, Los Angeles, Calif., 1969, Paper 69-WA/Inc-1.)

The history of municipal incineration, its present status, and possible future developments are reviewed. The first such in-

cinerator was built in Nottingham, England in 1874, but incinerator technology advanced most rapidly after World War II. Major breakthroughs in the early part of this period were the application of mechanical stokers to incineration and development of the continuous feed furnace. Plants which reclaim waste heat from incineration processes for production of steam power are currently receiving attention, but will probably be economically justifiable only in a relatively small number of large-scale centrally located installations. Air pollution control requirements are becoming increasingly stringent. Gaseous pollutants in incinerator stack effluents are generally so small in quantity that at present there are no control regulations; however, cleaning efficiencies as high as 95-98% on particulate emissions are either in effect or anticipated, especially for larger plants. At present, the only apparent means of approaching such efficiency is through the use of medium or high energy scrubbers, bag filters, or electrostatic precipitators. A first hand comparison of the operating characteristics of various cleaning systems will be available when several new plants in U. S. and Canadian communities have been in operation a sufficient length of time. Specially designed incinerations are being considered for incineration of bulky refuse. For the future, various slagging and pyrolytic processes present interesting possibilities for application to large scale municipal refuse disposal.

19896

Fernandes, John H.

**INCINERATOR AIR POLLUTION CONTROL EQUIPMENT.**

In: Technical Economic Study of Solid Waste Disposal Needs and Practices. Combustion Engineering, Inc., Windsor, Conn., Product Diversification Dept., Contract PH 86-66-163, Rept. SW-7c, Publ. 1886. 32p., Nov. 1, 1967. 3 refs.

The performance capability of the major classes of air pollution control equipment including mechanical collectors, wet scrubbers, electrostatic precipitators, fabric collectors, and settling chambers are presented. The relative capital and operating costs, water requirements and pressure drops for different air pollution control systems are also presented, together with design charts for system selection. Air pollution control equipment if properly designed, installed and maintained can meet stringent air pollution regulations. Of first importance to incinerator air pollution control is proper combustion within the burning system. Under these conditions, high efficiency mechanical collectors, wet scrubbers, electrostatic precipitators, and fabric collectors can meet present and projected incinerator air pollution control regulations. However, conventional wet and dry settling chambers will usually not be satisfactory. More knowledge of incinerator pollutants is required, and some application research must be conducted if this equipment is to be applied to incinerators with optimum results. Visual observations are not an accurate means to determine incinerator-stack emissions. Measurement of the pollution control capability of the burning system by sampling of the flue gas is recommended. Although an incinerator stack may appear reasonably clean because of the diluting effect caused by the extremely large quantities of air usually introduced into the burning system, the fly ash load in the gas may be excessive. Technology is not the limiting factor in controlling air pollution; rather it is the communities' willingness to finance the additional cost for sophisticated air pollution control equipment. It is estimated that present and projected emission levels can usually be obtained for a cost not exceeding 15% of the total plant cost.

19941

Eastlund, Bernard J. and William C. Gough

**THE FUSION TORCH: A NEW APPROACH TO POLLUTION AND ENERGY USAGE.** Preprint, American Institute of Chemical Engineers, New York, N. Y., 29p., 1969. 11 refs. (Presented at the American Institute Chemical Engineers Annual Meeting, 62nd, Washington D. C., Nov. 16-20, 1969.)

Disposal of future large volumes of solid wastes by the Fusion Torch concept, in which ultra-high temperature plasma is used to reduce material to its basic elements, is discussed. The properties of a fusion plasma, which has a temperature of approximately 50 million deg C, and of a future fusion power system based on a deuterium-tritium fuel cycle are reviewed. In such a system, the leakage, as an exhaust, of charged particle energy from the magnetic bottle would be utilized as the fusion torch. The kinetic energy of these 'leakage' charged particles can be converted into electrical energy by various methods: conversion efficiency for the charged particles would be limited to about 50% by thermal cycle considerations. An energy and material balance for processing U. S. municipal wastes in the year 2000 via this concept is developed and compared with such a balance for an advanced incineration system. Air pollution emissions from incineration of the projected quantities of refuse would be acceptable on a world-wide scale, while the fusion torch would release no pollutants to the atmosphere. Although the process has very high energy requirements, if the heat produced in the fusion torch section of the power system is converted to electricity at 50% efficiency, then no additional heat energy would be released to the environment. Unlike incineration, the fusion torch would be anti-entropic, i.e., would concentrate diffused material rather than diffusing the concentrated, and would thus also play a major role in conserving the world's supplies of mineral raw materials.

19987

Lenehan, Joseph W.

**AIR POLLUTION CONTROL IN MUNICIPAL INCINERATION.** J. Air Pollution Control Assoc., 12(9):414-417, 430, Sept. 1962. 9 refs. (Presented at the Air Pollution Control Association Annual Meeting, 55th, Chicago, Ill., May 20-24, 1962.)

The key to successful incinerator planning is the control of air pollution with special emphasis on fly ash collections: without control equipment, a 550 ton per day incinerator will produce 10,000 lb of fly ash per day. The various types of fly ash collectors available are discussed and a table of comparative data is presented for the collectors. Included in the table are the costs of the collectors in \$/CFM gas treated, efficiencies, space and water requirements, and gas treatment means. The lowest efficiency is indicated for settling chambers with sprays and the highest efficiencies for venturi scrubbers, glass cloth collectors, and electrostatic precipitators. It is noted that incinerator builders will have to become accustomed to the higher cost and space requirements of fabric filters. The application of these collectors to incinerators will also require greater control of combustion to prevent the formation of sticky soot which binds the filter cloth. The increase of combustibles in refuse and the development of continuous high-temperature indicate a possible field of application for fabric filters in incineration. In connection with electrostatic precipitation, problems of variation in the electrical properties of fly ash can be overcome by adding moisture to gases or combining a precipitator unit with a cyclone collector. The successful use of precipitators in incineration is anticipated.

20078

Priddy, Max H.

**MODERN APPROACH TO INDUSTRIAL AIR POLLUTION.** Ind. Gas, 50(5):9-14, May 1970. (Presented at the Midwest Industrial Gas Council, Chicago, Ill., Oct. 17, 1969.)

Early in 1967, a joint program was begun by Surface Combustion Division and the Columbia Gas Systems Service Corporation to instigate a complete research and development program in the area of pollution control. A laboratory was built in which the reaction kinetics of many hydrocarbon contaminants could be studied in terms of temperature requirements, reaction rates, and other variables. It is equipped with a blower, preheating temperature control, equipment for rapid mixing of a gas sample with an airstream, and a reaction chamber equipped with temperature and velocity measuring devices and oxidation rate analyzers. With this equipment, the comparative incineration rates of some common hydrocarbons have been determined at 1,410 F. A practical application of the program was the designing of commercial equipment, such as a stack incinerator for use with an exhaust airstream containing at least 15% oxygen; a 'packaged' stack incinerator complete with a fan, a complete line of controls, safety devices, and temperature instrumentation; and an injection incinerator for heavy-duty combustion systems operated at high temperatures.

20294

Celayan, Genaro G.

**SMOG-CONTROL EQUIPMENT FOR INTERNAL COMBUSTION ENGINES, INCINERATORS AND BOILERS.** (Assignee not given.) U. S. Pat. 3,499,282. 7p., March 10, 1970. 7 refs. (Appl. Oct. 13, 1967, 6 claims).

Smog control devices which eliminate volatile matter, carbon monoxide, and hydrocarbons from the exhausts of internal combustion engines, home incinerators, and boilers are described. An elongated chamber has an air inlet and an exhaust gas inlet at one end, with a series of butterfly vanes mounted for rotation along the length of the chamber. A spark-plug between each adjacent pair of butterfly vanes ignites the exhaust gas and air mixture as it passes along the length of the chamber. By means of the vanes, the chamber is divided into a number of separate blast chambers. The spark plugs provide a repetitive spark to give each blast chamber a source of heat energy to burn the volatile matter in the exhaust gases. As the vanes turn under the influence of moving gas, they permit the passage of the gas from one blast chamber to another where the remaining volatile matter is reduced and the CO gases are eliminated. Eventually, the processed gas passes from the last blast chamber and is then exhausted into the atmosphere.

20728

Cates, Henry J. Jr. and Tom Rosenberg

**MIXING CHAMBER FOR THE END OF AN INCINERATOR ROTARY KILN.** (Assignee not given.) U. S. Pat. 3,489,527. 5p., Jan. 13, 1970. 2 refs. (Appl. Oct. 19, 1966, 2 claims).

An arrangement is described for the discharge end of a rotary kiln employed in a continuous incineration operation. A hood arch configuration adjacent the discharge end of a rotary kiln extends downwardly in front of the kiln to protect the discharge end from the reflective heat which would be created in the mixing chamber into which the kiln discharges. An offset wall acts as a baffle to cause turbulence of the gases as they pass from the rotary kiln. A bridge wall acts as a baffle and a deflector and directs gases from the end of the rotary kiln back towards the gas flow from the kiln. (Author abstract)



20730

Ramires, Walter C.

**INCINERATOR FOR BURNING COMBUSTIBLE WASTE AND METHOD.** (Assignee not given.) U. S. Pat. 3,476,062. 5p., Nov. 4, 1969. 4 refs. (Appl. Dec. 13, 1967, 10 claims).

An apparatus is provided for aqueous scrubbing and mechanical drafting in the combustion zone and for comminuting of solid by-products to achieve essentially smokeless incineration of waste materials such as paper products, wood, garbage, and combustible plastics. The incinerator includes a combustion chamber with a perforated, rotating grate; a rotary impeller chamber; and a scrubbing chamber. Rotation of the rotary impeller causes the effluent from the combustion process, some of which continues to burn as it passes through the scrubbing chamber, to be drawn into the eye of the impeller. A spray nozzle in the scrubbing chamber is directed at the eye of the impeller; it generates a full cone of water droplets which pass through the burning product advancing to the impeller for mixing with the products and for joint centrifuging of the products and water in the impeller. In addition to providing positive drafting of the combustion chamber, the impeller also comminutes the solids in the effluents impinging on its face. Solids and gaseous matter are separated in a settling chamber downstream of the impeller, and the hot gases are recycled to the combustion chamber. The recirculation not only aids in the combustion of burning waste material but insures complete combustion of the recirculated gases.

20773

Luge, Karlheinz E. and Wolfgang Braun

**METHOD FOR COOLING THE COMBUSTION GASES OF REFUSE INCINERATORS.** (Metallgesellschaft A. G., Frankfurt (W. Germany)) U. S. Pat. 3,477,203. 3p., Nov. 11, 1969. 4 refs. (Appl. May 1, 1968, 7 claims).

A process is provided whereby the hot combustion gases of refuse incinerators may be readily cooled prior to their treatment in electrostatic dust separators, without unduly affecting the dew point of such gases or unduly increasing the volume of gases to be treated in the separators. In the first step, a cooling liquid is injected directly into the hot gases while they are still in the furnaces in the incinerator plants so as to lower the temperature of the combustion gases to about 600 C. In the second step, the temperature of the gases is further reduced to about 300-400 C by the infiltration of atmospheric air into the gases. The cooling liquid, usually water, is injected into the furnace under such conditions that it becomes and remains completely vaporized in the furnace so as to prevent the formation of sludge.

21058

Ishitsu, Fumio

**SMOKE AND DUST PROCESSING EQUIPMENT.** (Baien Shori Sochi). Text in Japanese. (Assignee not given.) Japanese Pat. Sho 44-28069. 3p., Nov. 19, 1969. 1 ref. (Appl. March 5, 1964, claims not given).

A method for separating soot from the smoke emitted by an incinerator is described. Above the smoke flue, from the side of the incinerator, a boiling water tank, water tank, and smoke exhaust fan are provided. When the smoke passes the flue under the boiling water tank, it is mixed and moistened by the steam of the boiling water which comes from small holes in the bottom plate of the tank. Secondly, passing the flue under the water tank, the soot in the smoke absorbs the water which drops from holes in the bottom of the tank. The smoke is blown through the chimney by the exhaust fan.

21435

Brion, Jacques, Michel Cousin, Wulf Talejinski, and Andre Volk

**GAS FILTERING INSTALLATION.** (Commissariat a l'Energie Atomique, Paris (France)) U. S. Pat. 3,479,800. 10p., Nov. 25, 1969. 3 refs. (Appl. July 24, 1967, 10 claims).

An installation is described which is very suitable for filtering hot gases including the smoke from waste incinerators, since not only can it provide rapid and completely safe cleaning of the filters whenever necessary, but also it can use filter elements in the form of porous tubes lined with a fibrous deposit and is able to withstand heat very well. The installation comprises a casing, porous filtering tubes disposed in side-by-side relationship, a supply line communicating with the interior of the tubes, and an exit line with the outside of the tubes. A number of tubular probes are located above the filtered tubes, rigidly interconnected and connected to a suction system, with apparatus for moving them from a withdrawn position above the tubes during filtering and a position in the tubes for sucking deposits away from the inner walls of the tubes. A unit for spraying a fibrous lining into the cleaned and stripped porous tubes is also included.

21626

VDI (Verein Deutscher Ingenieure) Kommission Reinhaltung der Luft, Duesseldorf, Germany, Unterausschuss Abfallverbrennungskleinanlagen und VDI (Verein Deutscher Ingenieure) Fachgruppe Haustechnik, Duesseldorf, Germany

**RESTRICTION OF EMISSION WASTE INCINERATION IN PLANTS WITH THROUGHPUT OF UP TO 1,500 KG PER HR.** (Auswurfbegrenzung Abfallverbrennung in Anlagen mit Durchsatzleistungen bis zu 1500 kg/h Abfall). VDI (Ver. Deut. Ingr.) Richtlinien, no. 2301, Feb. 1967. 35 refs. Translated from German by D. Ben Yaakov, Israel Program for Scientific Translations, Jerusalem, 9p. CFSTI: TT 68-50469/13

The formation and control of emissions from small solid-waste incinerating plants close to the waste source, rather than from large central incineration plants, are reviewed, and emissions limits are given. General design and construction requirements are given for release of flue gases, auxiliary burners, secondary combustion, inspection and measuring openings, charging gear, incinerator premises, operation, and heat recovery processes. Factors affecting dust and soot formation in the different parts of the incinerator are outlined, as well as engineering means of removing particulate and gaseous components in the flue gases, and the equipment, operating, and maintenance requirements for restricting emission. Smoke-plume color must be less than No. 2 on the Ringelmann scale for running operation with any type of waste, and less than No. 1 with the waste type for which the unit is designed. Particulate emission may not exceed 200 mg/cu m STP for moist flue gas (with CO<sub>2</sub> content of at least 7%) at the stack outlet, to be determined by gravimetric measurement during a period representative of average operation.

22156

Joffre, R.

**ELECTROSTATIC DUST REMOVAL IN URBAN INCINERATORS AT THE ELECTRICITE DE FRANCE-TIRU PLANT, ISSY-LES-MOULINEAUX.** (Depoussierage electrostatique de l'installation d'incineration des residus urbains a la centrale E.d.F.-Tiru--Issy-les-Moulineaux). Text in French. Tech. Moderne, p. 49-50, Feb. 1970. (Presented at the University Foundation for the Study of Air and Water Pollution Congress on Dust Rembval, Lyon, France, April 24, 1969.)

The Issy-les-Moulineaux incinerator can handle 500,000 tons per year of garbage and household trash, with an average thermal power of 1500 kcal/kg. It is divided into 4 independent units, each of which is equipped with 2 Lurgi electrofilters and blower that draws the fumes from the 2 filters into a common chimney. The installation is the first of its size to be used in Europe. The dust separators are 98% efficient, receiving waste gases containing 80-360 mg/cu m and emitting gases containing 4-18 mg/cu m. The filters are in a horizontal position, connected in parallel, each with two electrical fields, independent from one another and connected in series, so that in the case of a failure of one field the unit will retain 75% operating efficiency. A major problem in the use of electrostatic filters with incinerators is that fragments of partially burned paper, because of their high carbon content, do not respond to the electrostatic field and escape into the air. Experimental studies have shown that the use of precipitation plates with irregular surfaces is more effective in eliminating the paper ash.

22296

Day and Zimmermann, Inc., Philadelphia, Pa.

**SPECIAL STUDIES FOR INCINERATORS FOR THE GOVERNMENT OF THE DISTRICT OF COLUMBIA.** PHS Grant D01-SW-00038-01, Rept. SW-1d, PHS Publ. 1748, 80p., 1968. 84 refs.

Six special studies, prepared as a part of the evaluations leading to a design for an incinerator for the District of Columbia, is presented. Topics of the studies include: incinerator effluent gases, control laboratory, size reduction of oversize burnable waste, size reduction of bulky metal objects by compression presses, heat recovery, and can-metal recovery. The incinerator effluent stream contains inorganic and organic substances in the form of gases and particulates. Some of these constituents are toxic and corrosive. Electrostatic precipitators preceded by mechanical collectors are recommended for air pollution control. Itemized lists of instrumentation and laboratory equipment and their estimated installed costs are presented. The installation of a shredder for size reduction is recommended. The use of compression presses to reduce the size of bulky metal objects is acceptable under certain conditions; the alternate use of outside contractors for metal shredding as a potentially more economical solution is recommended. The economics of the proposed plant do not justify the installation of heat recovery equipment. Because of the low price obtainable for recovered can metal, it is concluded that facilities of this type should not be included in the proposed incinerator project. (Author abstract modified)

22757

Kaiser, E. R., J. Halitsky, M. B. Jacobs, and L. C. McCabe  
**MODIFICATION TO REDUCE EMISSIONS FROM A FLUE-FED INCINERATOR.** New York Univ., N. Y., Research Div., Tech. Rept. 552.2, 51p., June 1959. 8 refs. (Presented at the Air Pollution Control Assoc. Annu. Meet., 52nd, Los Angeles, Calif., June 1959.)

A program of 38 tests was conducted on three flue-fed, single-chamber, refuse incinerators in three 16-story apartment buildings to determine the amount of atmospheric pollution from the incinerator flues and the effectiveness of several appliances in reducing the emission of atmospheric contaminants from such incinerators. Tests were conducted on the use of overfire air jets, supplemental gas firing, a stainless-steel secondary combustion chamber, a method of high-rate combustion, and a flue-gas scrubber. The devices are illustrated, test methods described with resulting data, and the emissions are reported and compared with those from the unmodified in-

cinerators. Estimated investment and operating costs for the incinerator modifications are included. Emissions of atmospheric contaminants from the incinerator flues can be reduced by each of the following methods, and that the best results are obtained by all of them in combination: by hopper locks to prevent the charging of loose particles of dust, paper, lint, etc., while the velocities in the flue are high, as when refuse is burning; by appliances that promote better combustion in the furnace; by care taken by the incinerator operator to limit the flow of air through the grate during burning and through and over the residue during its removal; and by scrubbing the flue gas before discharge to the atmosphere. (Author summary modified)

22808

Chansky, Steven H., Anne N. Dimitriou, Edwin L. Field, Charles R. LaMantia, and Robert E. Zinn

**SYSTEMS STUDY OF AIR POLLUTION FROM MUNICIPAL INCINERATION. VOLUME III. (BIBLIOGRAPHY).** Little (Arthur D.) Inc., Cambridge, Mass., NAPCA Contract CPA-22-69-23, 64p., March 1970. 544 refs. CFSTI: PB 192380

A bibliography of selected references on incineration is presented as Volume III of a three volume report on air pollution from municipal incineration. The scope of the study, conclusions, and recommendations are presented in Volume I; Volume II consists of appendices to the report. Subject areas included in the bibliography include the location, number, capacity, and design characteristics of U. S. and foreign incinerators; refuse quantity and quality; emission data; effect of design and operating parameters on emissions; performance of air pollution control devices; economics of incineration; new concepts of incineration; other methods of refuse disposal; and a miscellaneous category which includes data on population, rainfall, and similar useful information. An author index is included.

22821

Biswas, B. K. and R. H. Essenhigh

**SOME CHARACTERISTICS OF STABILIZED SMOKE FLAMES.** Combust. Flame, 15(1):93-96, Aug. 1970. 4 refs.

Experiments are being carried out to provide more details on the flames produced when an aerodynamic flameholder is utilized to reduce incinerator smoke. Four types of flame are illustrated, the prime variable leading to the changes being an increase in the air/fuel ratio. When the incinerator is hot there should be little risk of smoke emission so long as overbed mixing is reasonably good, but when the walls are cold, which occurs periodically with intermittently operated units in apartment blocks, the smoke will not burn unless there is a flameholder. Smoke is experimentally generated at the bottom of a vertical steel pipe, 3 in. in diameter and about 3 ft long, by incomplete combustion of chad from computer cards. Injection of secondary air through eight ports near the top of the pipe is designed to produce two vortex flows rotating in opposite senses. The eight injection ports are split in two sets and the shear between the two flows generates intense turbulence with substantial backmixing. As illustrated by the photographs, this method of stirring produces a clean-burning smoke flame with fairly clearly defined inner and outer cones. Chemical composition of the smoke is also mentioned.

22822

Kaiser, Elmer R. and Joseph B. McCaffery

**OVERFIRE AIR JETS FOR INCINERATOR SMOKE CONTROL.** Combustion, 42(2):20-22, Aug. 1970. 3 refs. (Presented



at the Air Pollution Control Association, Annual Meeting, 62nd, New York, June 26, 1969, Paper 69-225.)

Jets of air directed into the flames from incinerator fuel beds aid in completing the combustion of gases and suspended carbon particles. As the location, sizing, and pressurizing of the overfire air nozzles are important design considerations for air pollution control, tests on overfire air jets were conducted to determine their performance in reducing smoke from a large incinerator furnace. The total amount of excess air was satisfactory, because the carbon dioxide content of the flue gas seldom exceeded 7%, dry volume basis. Overfire air velocity measurements in the cold-furnace revealed that velocities declined rapidly within the first 4 feet from the nozzles and then fell off more slowly with distance. The certain sidewall nozzles were particularly weak and would not deliver air to the center of the furnace. Typical velocities are presented graphically, as well as air flow and jet penetrations at 1500 fpm as functions of nozzle diameter and pressure differential. Equations are presented for calculating the flow through an overfire air nozzle and for calculating jet throw for a terminal velocity of 1500 fpm. The second graph is useful for the selection of nozzle sizes and air pressures. A method to increase air penetration from the sidewall air nozzles is also mentioned.

23008

Vandaveer, F. E.

**THE DOMESTIC GAS-FIRED INCINERATOR'S ROLE IN AIR POLLUTION CONTROL.** J. Air Pollution Control Assoc., 6(2):90-97, Aug. 1956. 15 refs.

Progress in the development of a smokeless, odorless, fly ash-free, domestic gas-fired incinerator is reported. Test charges and methods for producing and determining odor, smoke, and fly ash were selected. Two-stage incineration with gas heat in both stages is necessary to eliminate smoke and odor from domestic incinerators, the first stage for burning the garbage and paper, the second stage for oxidizing the smoke and odor. For second stage incineration, catalysts impregnated on porcelain or on chrome alloy heated to 500-700 F, ceramic balls or slabs heated to 1400-1500 F, stainless steel grids heated above 1400 F, smokeless downdraft combustion with a gas afterburner, and the flame of a gas-fired afterburner may be used. Drawings of two prototype models of smokeless, odorless and fly ash-free incinerators, and test data on them, are presented. Major changes and additions to gas association requirements for approval of domestic incinerators are reported. Drawings are presented of two commercially-developed incinerators being field-tested, one with a gas-heated catalyst in the second stage and the other with downdraft combustion and a combined incineration burner and gas flame afterburner. Calculations made from published data show that an incinerator in every house in a large city should not cause an increase in nitrogen oxides, sulfur dioxide, or aldehydes in the atmosphere to anywhere near the allowable maximum level for health. (Author summary modified)

23262

Ito, Akio, Tadao Shirasawa, Tomio Ohyanagi, and Yukio Tamori

**PACKED COAL BED AS A DUST COLLECTOR (II).** Taiki Osen Kenkyu (J. Japan Soc. Air Pollution), 2(1):98-100, 1967. Translated from Japanese. 8p.

Dust collection using packed coal was studied for treatment of the exhaust of coal-fired furnaces and incinerators. The coal from which smoke was collected was fed into a combustion

chamber, so that no dust trapping device was needed and operation could be achieved with only a single collector. Generally, in the case of filtration, collection efficiency is improved due to the deposition of smoke on the filter. However, the flow rate of gases is reduced due to thickening of the smoke layer, provided that the power of the suction or blower is maintained constant. Consequently, it is uncertain whether the rise of collection efficiency was due to formation of the dust layer or to the reduction of flow rate. In this experiment, the equipment was improved so that both effects could be separately evaluated. An experimental equation of pressure loss and collection efficiency was derived for a nearly uniform size of coal layer which was produced by sieving. An experiment was also conducted on packed beds of spherical active carbon and glass spheres in order to elucidate the feature of the coal bed in comparison with the above two standard beds. In this type of collector, the amount of coal employed for dust collection and that consumed for the combustion was balanced; this requirement imposed restrictions on the thickness of packed bed, flow rate of exhaust gas, area of beds, and interval for replacement of coal. For a given coal consumption, the gas flow rate was roughly determined, and the area of the bed was derived from the optimum face velocity. Beds of 7 and 14 cm thickness were tested. On determining the optimum thickness of the beds, the interval of time for the replacement of coal was derived. This procedure provided the standard for practical design of a coal bed. The smoke-laden gas of fixed volume was drawn through circular filters up and downstream of the smoke collector, and the amount of smoke was determined by measurement of light reflectivity of the filter surface on which the smoke was deposited.

23482

Brandt, H. and H. Heer

**PARTICULAR DEDUSTING PROBLEMS IN REFUSE INCINERATION PLANTS.** (Besonderheiten bei der Entstaubung in Muellverbrennungsanlagen). Text in German. Mitt. Ver. Grosskesselbesitzer, 48(2):118-126, April 1968. 6 refs. (Presented at the 'Refuse Incineration' Sessions of the VGB, held Feb. 9, 1968 at Hamburg; Feb. 16, 1968, at Munich; and Feb. 23, 1968, at Duesseldorf.)

The possibilities of using various dust removal systems for the purification of waste gases from incinerator plants are discussed in the light of standards set by governmental regulations. The incineration system is affected by the type of construction, i.e., the presence or absence of heat utilization and whether waste gases are cooled with cold air or with a water spray. Consideration is given to such operational problems as the retention of paper fly ash and the burning of auto tires. Structural requirements are examined, and observations under actual operation are reported. Illustrative material gives some indication of the appearance and size of such plants. Exhaust gases, as they leave the incinerator, are at a temperature of 800-1200 C. Mechanical dust separators using special sensitive materials can withstand a temperature of 750 C, those using insensitive materials can withstand 480 C, and electrostatic filters made of conventional materials can resist temperatures up to 400 C. In providing the means for cooling these gases, an additional safety margin of 50 degrees should be allowed. Cooling can be achieved by cooling the surface of the channels through which the gases pass, by the use of a water spray which absorbs vaporization heat as it turns to steam, or by mixing cold air with the gases. Among the types of dust removal equipment examined are mechanical devices, scrubbers, and electrostatic filters.

23542

Smauder, Ellis E.

**PROBLEMS OF MUNICIPAL INCINERATION.** Air Pollution Control Assoc., Los Angeles, West Coast Section, Proc. Air Pollution Control Assoc. West Coast Sect., 1st Tech. Meet., Los Angeles, Calif., 1957, p. 69-81. (March 25-26.)

A study of 15 municipal incinerators with rated capacities from 200-900 tons per hr and built within the last 10 years at a total cost of more than \$60,000,000 revealed that none would meet full rated capacity without exceeding the most liberal fly ash and smoke abatement codes and the usual requirements of less than 3% of combustible organic matter in ash residue at the ash pit. The results can be partly attributed to batch charging systems which make it difficult to maintain a well-balanced fuel-air ratio. A well-designed municipal incinerator will incorporate methods for continuous and automatic charging of materials as received, continuous and automatic stoking, and continuous ash removal. Such provisions eliminate interference with combustion air supply and control now experienced in widely accepted designs based on batch charging and stoking. Other equipment necessary for efficient incinerator operation are induced draft systems, wet fly ash collectors, and mechanical sludge removal systems. Results of ash residue and dust loading measurements from two well-designed municipal incinerators are presented as evidence that most troublesome incinerator problems can be overcome.

23819

Davies, Theodore E.

**FLAME GRID AND COMPONENT PARTS THEREOF.** (North American Mfg. Co., Cleveland, Ohio) U. S. Pat. 3,524,632. 27p., Aug. 18, 1970. 4 refs. (Appl. June 12, 1968, 67 claims).

The invention relates to direct-fired, flame-grid type burners using substantially raw fuel to heat a gaseous stream such as air or gas (carrying or not carrying combustibles, including fumes, to be incinerated). The burners have structures that make them suitable for use in a make-up air heater, air space heater, oven, dryer, evaporator, draw furnace, or fume or combustible incinerator. They can handle temperature rises from 3 to 1500 F. Each burner has a long turn-down range and plate-like portions with flow opening or edge portions for diverting some stream portions into a combustion zone on a flame holder and subsequently mixing the combustion products with all air stream portions for uniform heating or incineration. In addition to having minimum initial and operating costs, the burners meet the highest incineration standards. (Author abstract modified)

23836

LaRue, Phillip G.

**SMOKELESS AND ODORLESS DOMESTIC INCINERATORS.** (Calcinator Corp., Bay City, Mich.) U. S. Pat. 3,527,177. 7p., Sept. 8, 1970. 7 refs. (Appl. Jan. 4, 1968, 12 claims).

An incinerator for the smokeless and odorless burning of domestic rubbish is described. The off-gases of the primary combustion chamber are channeled into the path of a torch-like burner where they are heated to an elevated temperature, mixed with additional oxygen, and forced to take a definite time-delay path in order for recombustion to take place before the gases are vented to the atmosphere. A venting mechanism is provided which reduces the temperature of the gases from the secondary chamber before they are released to the atmosphere. The incinerator is of a compact and efficient design and utilizes a minimum number of parts.

23856

Khan, A. A., R. V. Amalraj, and K. T. Thomas

**FABRIC FILTRATION OF FLUE GASES FROM AN ACTIVE INCINERATOR: STUDIE ON DESIGN OPTIMIZATION AND OPERATIONAL ANALYSIS.** International Atomic Energy Agency, Vienna (Austria), Treat. Airborne Radioact. Wastes, Proc. Symp., New York, 1968, p. 623-644. 1 ref. (Aug. 26-30.)

The use of bag filters in the dry gas cleaning system of an incinerator is a safe and economical method for treating the flue gas from an incinerator burning low-level radioactive solid combustibles. A study designed to gather operational data which is directly applicable to the design of fabric filtration units for industrial plants is described. Various types of fabrics, including cotton, terylene, wool, dacron, and glass, are evaluated to find the filtration characteristics during the entire cycle of operation. Data on pilot plant studies carried out to optimize a suitable design of fabric filter for flue gas cleaning is included. Cost comparisons of different fabrics based on the life of the fabric and the cost of the fabric filtration per unit of solid waste treated are given. The physical, chemical, and radiochemical nature of the aerosols encountered in various parts of the incinerator system are described. (Author abstract modified)

24089

Calaceto, Ralph R.

**ADVANCES IN FLY ASH REMOVAL WITH GAS-SCRUBBING DEVICES.** Filtration Eng., 1(7):12-15, March 1970.

The adoption of the multiple-hearth furnace in servicing sludge incineration has offered the prime advantage over other devices in that counter-flow feed of wet sewage cake to the exhaust gases creates a progressive drying as the sludge descends from hearth to hearth and, finally, into the burning or incineration zone. A very simple scrubber, which consisted of an enlarged duct with sprays that partially cooled the gases, was the first gas-cleaning device to follow the multiple-hearth furnace. In recent years, new multiple-hearth furnaces have been designed to include afterburners, to assure complete combustion prior to scrubber treatment of such volatiles as grease and tar vapor. Within the past year, a new device, the Mikro-Airetron venturi scrubber was installed at the sludge incinerator plant in Orangeburg, New York. The fine droplets created by the carefully monitored gas acceleration combine and coalesce with the fly-ash particles, removing particles down to sub-micron size. Operation of this venturi scrubber is described. The Orangeburg installation is also provided with a cooling stage, just following the venturi, which serves to reduce the usual saturation temperature of 170 to 185 F down to 110 F.

24465

Billard, F., J. Brion, M. Cousin, and R. Delarue

**HIGH TEMPERATURE FILTER FOR THE PURIFICATION OF INCINERATOR GASES.** (Filtre a haute temperature pour l'epuration des gaz d'incinerateur). Text in French. International Atomic Energy Agency, Vienna, Austria, Proc. Symp. Operating, Developmental Experience in the Treatment of Airborne Radioactive Wastes, New York, 1968, p. 659-665. 4 refs. (Aug. 26-30.)

A recoverable filter for hot incinerator gases is described. This consists of metal foil cylinders on which asbestos fibres have been deposited by pneumatic spray to constitute the filtering medium. The special feature of its operation lies in the fact that partial burnt materials from the incinerator, especially



lamp black, complete their combustion on the filter, as they are produced. This greatly reduces choking of the filters, which are expected to operate for several hundreds of hours between cleanings. This filter has been tested on a reduced-scale model followed by a long period of industrial use in a pilot plant with a capacity of 20 kg/h. The plant is described and the results obtained are presented. (Author abstract modified)

24954

Combustion Power Co., Inc., Palo Alto, Calif.

**COMBUSTION POWER UNIT -- 400: CPU-400.** Bureau of Solid Waste Management Contract Ph 86-67-259, 15p., 1969. NTIS: PB 187299

Development has begun on a turbogenerator electric plant that will utilize 400 tons of municipal solid waste per day to produce up to 15,000 kw of electric power. The baseline configuration is a modular unit that is expected to be clean, compact, and quiet. Such units could be conveniently dispersed throughout a city to supplement power supplied by local utilities. The major components of the system are a refuse carousel, a mechanical shredder, a refuse combustor using a fluidized bed reactor, a two-stage particle collector packed with the fluid bed reactor, a 15 megawatt gas turbine, and a 3600 rpm generator. Using either available energy or by-products from the combustion steam, add-on systems to the basic unit provide (1) automated vacuum collection of refuse, (2) fresh water produced from saline or brackish water, (3) centralized steam for commercial heating and air conditioning, and (4) incineration of sewage sludge. Estimated capital and operating costs of the plant are summarized, as is the expected income from electric power, steam, and by products. Costs for refuse disposal may be as little as 95 cents per ton.

25511

McClure, Elson R.

**SMOG ARRESTER.** (Assignee not given.) U. S. Pat. 3,533,608. 3p., Oct. 13, 1970. 5 refs. (Appl. Aug. 2, 1968, 1 claim).

A vertical tank-like structure is described which comprises superimposed sections, provided with alternate central and peripheral baffles, of which the latter have axial openings of smaller diameter than the outside diameter of the central baffles to cause products of combustion to flow radially inward and outward as they move upward. The apparatus is adapted to be placed at the top of any structure from which products of combustion flow, such as an incinerator or stack, which might emit objectionable smoke, fumes, or gases. Heat of the products of combustion cause them to flow upward, and water sprays impinge against the bottoms of the central baffles. The weight of the water sprays causes the water to flow downward, thus picking up solid matter from the products of combustion. (Author abstract)

25570

Lausmann, Jerry S.

**BURNER MEANS FOR ELIMINATING SMOKE.** (Assignee not given.) U. S. Pat. 3,538,865. 14p., Nov. 10, 1970. 19 refs. (Appl. May 26, 1969, 17 claims).

A device for eliminating the smoke arising from incomplete combustion of wood waste products is described. The device consists of a tepee burner which have the ability to concentrate at the burner axis the particulate matter which is produced in the combustion process and to collecting and draw off the axial column of particle bearing gases while allowing the clean peripheral combustion gases to be discharged

into the ambient air. Ducts return particle bearing gases to the lower portion of the burner where fans inject the gases into the burner through a wall of flame to incinerate much if not all of the particulate matter; the injection is carried out so as to aid the concentration of the particulate matter in the axial columnar portion of the rising combustion gases. Control means are provided for regulating the temperature of the returning combustion gases in relation to the temperature at the tepee outlet so as to maintain the temperature of the burning pile at or near an optimum value thus decreasing the amount of particulate matter produced in the combustion process. Previous burners pollute the atmosphere with smoke because of incomplete combustion; the device described controls that pollution. (Author abstract modified)

25706

Zalman, Solomon

**ANTIPOLLUTION APPARATUS.** (Assignee not given.) U. S. Pat. 3,530,807. 7p., Sept. 29, 1970. 6 refs. (Appl. April 28, 1969, 9 claims).

An antipollution apparatus for removing the smoke particles from exhaust gases of an incinerator of fuel burning apparatus is described, having a plurality of spiral coils with steam jets mounted against the internal walls of the chimney adjacent to its opening and supplied with steam under pressure. As an incinerator, the apparatus also utilizes a gas burner for igniting the refuse articles, and an air blower having an air jet manifold for maintaining a high temperature of combustion within the incinerator. The apparatus also includes a control panel connected to a temperature dispensing device for operating the gas burner, and air blower to maintain a high temperature of combustion within its combustion chamber. Previously, smoke precipitation devices such as electrostatic fields and steam spraying apparatus have been used; however, electrically operated devices are costly to install, expensive to operate, and are often unreliable. (Author abstract modified)

25977

Osterli, Victor P.

**AIR POLLUTION CAUSED BY AGRICULTURE AND FORESTRY: ODOR.** In: Project Clean Air. California Univ., Berkeley, Task Force No. 5, Section 6, 4p., Sept. 1, 1970. 20 refs.

The development of methods to control odor at the site and for disposal of livestock and poultry fecal matter is a major need. One possible process, wet oxidation, could be of real significance since it would not only eliminate the fecal matter but would produce energy to carry out the disposal process and possibly even convert the wastes to animal feed. Treating the manure with chemical deodorants may provide a partial solution. A specific application of the pyrolysis-combustion process could be an alternative to current methods of incineration used which would eliminate or substantially alleviate the problem of malodors. Afterburner-type devices are available for some kinds of rendering plants to control odors. In addition to animal wastes and odors from meat processing and rendering plants, more than 28 million tons of wood pulp are produced yearly in the United States by the sulfate or kraft process which produces a pollution problem.

26063

Rathgeber, Ferdinand

**ELECTRIC FILTERS FOR DRY AND WET SEPARATION.** (Elektrofilter fuer Trocken- und Nassabscheidung). Text in German. Wasser Luft Betrieb, 14(1):456-460, Nov. 1970.

Recent improvements of electric filters deal with increasing operating reliability, with increasing capacity, with prolonging the life of the equipment, and with adapting the equipment to properties of different dusts. As a result, various modifications of sparking and of precipitation electrodes were produced. In some areas, a combination of electric filtration with other dust removal methods was found advantageous. The trend is towards the building of compact units. Another improvement consists of the introduction of unbreakable electrodes. Wet electric filters have not found as wide application as dry filters. A newly developed wet filter consists of a battery of

identical wet elements intended for the separation of aerosols, of dust, of soot, and for the recovery of valuable waste gas components. Examples of the application of improved dry and wet electric filters include dust separation of power plant flue gases and of larger incinerator flue gases which sometimes must be cooled prior to dust removal, dust separation in cement manufacture, gas purification in non ferrous metal smelting plants, the recovery of valuable materials from waste gases from metallurgical processes, and dust removal in the iron and steel industry.



## C. MEASUREMENT METHODS

01612

W. L. PRITCHARD, C. E. SCHUMANN, C. W. GRUBER

**PARTICULATE SAMPLING BY ADHESIVE-COATED MATERIALS (PROGRESS REPT. NO. 2).** Cincinnati Division of Air Pollution Control, Ohio, Dept. of Safety. Oct. 1, 1966. 111 pp.

For the past 12 years the Cincinnati Division of Air Pollution Control has been using adhesive-coated paper wrapped around circular glass jars for tapping wind-blown particulates. The primary objectives were: (1) determine the adhesive material(s) best suited for the method; (2) determine the mechanism(s) of particle collection; (3) determine the environmental and mechanical factors affecting the collection efficiency; (4) devise a relatively simple and rapid means of evaluating the samples collected; (5) if practical, identify and classify particles collected; (6) apply the criteria developed and the results obtained above, to one or more area surveys; and (7) improve the prototype model of a source sampling device which utilizes a continuously moving adhesive-tape for particle collection. When sampling jars with Pli-A-Print R-135 are placed in open areas for atmospheric monitoring, the concentration of wind blown particulates at two or more separate locations are considered to be significantly different when the total concentration of particles collected varies by more than 8%. When comparing the concentration of particulates at two locations, it is important to have both jars at the same height and in an open area. When it is impossible to locate the adhesive cylinders in open areas at the same height, the significant difference becomes 20% for total particle concentration. The 'mean diameter' of the captured particles is approximately 40 microns. The particles captured on the roof at the City of Cincinnati Division of Air Pollution Control building had the following distribution: 56% black, 16% chromatic, and 28% transparent or gray. It is possible, by using the sampling jar and wind instruments, to determine local sources of wind blown particulates and to observe the effect rain has in lowering the concentration of wind blown particulates in the atmosphere. The collection efficiency of Pli-A-Print R-135 varies with each incinerator tested from 7.4% to 3.3% as indicated by the experimentation accomplished to date. In addition, it has been possible to repeat collection efficiency tests and obtain the same results.

02260

M. J. Salkowski

**PROTOTYPE FLY ASH MONITOR FOR INCINERATOR STACKS (FINAL REPT. APR. 15, 1963 - JULY 14, 1964.)** IIT Research Inst., Chicago, Ill., Technology Center. (Rept. IITRI-C8015-5.) July 1964. 54 pp.

This program resulted in the construction of a prototype instrument for the analysis of fly ash emitted from municipal incinerators. The instrument was proved both in the laboratory and in the field. The instrument samples a predetermined amount of stack effluent isokinetically, separates the particulate material in a cyclone, collects a representative sample of fly ash on filter paper, and measures the amount of sample by a gravimetric technique using a beta-gauge principle. The en-

tire concept is designed to function on a routine basis and be operated by unskilled personnel. (Author abstract)

02369

M.J. Salkowski

**PROTOTYPE FLY ASH MONITOR FOR INCINERATOR STACKS (ADDENDUM TO FINAL REPT.)** IIT Research Inst. Chicago, Ill. Jan. 1965. 23 pp.

A simple analog-digital circuit for the generation of a frequency that is proportional to mass flow has performed satisfactorily. The circuit permits the temperature-sensing resistor to be in a location remote from the computer and requires no amplification of the temperature signal, since the resistor is a purely passive circuit element. (Author summary)

02391

L. V. Edwards.

**SMOKE DENSITY MEASUREMENT IN MUNICIPAL INCINERATORS.** Proc. Natl. Incinerator Conf., New York, 1966 183-6, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

The opacity or optical density of smoke in the breeching or stack of a municipal incinerator is an index of combustion. The smoke meter is a useful operating guide, rapid in response. The paper describes the theory and principles of the modern smoke meter and types of readout. It is a guide for the selection, specification and installation of smoke alarms, and recording smoke charts. (Author abstract)

04117

F. R. Rehm

**TEST METHODS FOR DETERMINING EMISSION CHARACTERISTICS OF INCINERATORS (INFORMATIVE REPORT NO. 2).** J. Air Pollution Control Assoc. 15, (3) 127-35, Mar. 1965.

In considering the problem of incinerator air pollution emission characteristics, early attention must be given to defining the type discharges which are of greatest concern. At this time the following 3 categories of incinerator effluents-visual emissions (smoke), particulates, and odor are of primary interest. It is in these 3 areas that the greatest present need exists with respect to air pollution performance evaluation standards or limitations and standardized test methods. It is toward the standardization of testing of these 3 classes of incinerator effluents that this report is pointed. Visual Emission Testing: Until some better tool evolves, the Ringelmann Chart will undoubtedly serve as the most frequently used method for assessing visual smoke emissions from incinerators and other combustion equipment. In recent years refinement of techniques has allowed for the grading of colored effluents other than black or white. Other applications in this category have included paper tape filters and photoelectric devices. Odor Testing: A 1961 Performance Evaluation Sub-Committee survey disclosed that only a limited amount of work has been

conducted on odor testing of incinerator effluents. The human nose has been relied upon to a great extent. The ASTM Standard Method for Measurement of Odor in Atmospheres (Dilution Method) D 1391-57 involves sampling the gas for which the odor is to be measured and then diluting it with odor-free air until an observer can barely perceive the odor. Particulate Testing: This has involved various approaches to attain the following: (1) a representative sample of gas and suspensoid from a main gas stream; (2) filtering the particulates from the sampled gas stream; (3) accurately measuring the sampled gas volume; (4) measurements to assess total emission characteristics temperature, pressure, gas velocity, composition, molecular wt, density. In summary, it is the Performance Evaluation Sub-Committee's opinion that the ASME Test Codes PTC 21-1941, 'Dust Separating Apparatus' and PTC 27-1957, 'Determining Dust Concentration in a Gas Stream,' with modifications and additions as discussed, could form the basis of an acceptable standardized test method for determining incinerator particulate emission characteristics.

05834

M. Feldstein

**STUDIES ON THE ANALYSIS OF HYDROCARBONS FROM INCINERATOR EFFLUENTS WITH A FLAME IONIZATION DETECTOR.** (J. Air Pollution Control Assoc.) 12, (3) 139-41, Mar. 1962. (Presented at the 54th Annual Meeting, Air Pollution Control Association, New York City, June 11-15, 1961.)

Flame ionization units capable of detecting small concentrations of hydrocarbons make use of the principle that when a hydrocarbon is introduced into a hydrogen flame, electron concentrations are formed and can be measured. The thermionic work function for carbon is 4.35 electron volts which, apparently, is low enough for electron emission at hydrogen flame temperatures. The response of the instrument is proportional to the number of carbon atoms in the compound being burned; that is, hexane will give six times the response of methane. The instrument can thus be considered as a carbon counter. Apparatus and equipment included a Carad flame ionization analyzer and detector, recorder, a Carad gas sampling unit, and stainless steel collecting tanks. A 30 ml sample of effluent was injected and yielded a reading proportional to the total hydrocarbon content of the sample. A second 30 ml sample was then injected with the silica tube in line. Response due to methane, ethane, ethylene, and acetylene was then noted on the recorder as these gases separated on the silica column. The difference between the total hydrocarbon reading and the methane reading is proportional to the C2-C6 hydrocarbons present in the sample. The same samples were also analyzed by gas chromatography. By converting the results obtained with each method to similar units, direct comparison may be made. For the series of effluents analyzed, agreement between the two methods is excellent. The flame ionization method lacks adsorption properties of particle and surface. Adhesion of provides a more rapid procedure for the analysis and may be considered as a comparable method for the analysis of C2 and higher hydrocarbons.

06095

C. V. Kanter, R. G. Lunche, A. P. Fudurich

**TECHNIQUES OF TESTING FOR AIR CONTAMINANTS FROM COMBUSTION SOURCES.** J. Air Pollution Control Assoc. 6 (4), 191-9 (Feb. 1957). (Presented at the 49th Annual Meeting, Air Pollution Control Association, Buffalo, N.Y., May 20-24, 1956.)

The Air Pollution Control District (APCD) in the past 8 years has made more than 800 test, including many on incinerators

and power plant boilers. The techniques used in testing these combustion sources are described. These techniques are based on principles and procedures which have been in use for many years and have been described in the literature. In most air pollution control studies of combustion sources, attention has been largely focused on the amount of particulate matter discharged. In the testing program of the APCD, methods for measuring other contaminants in the gaseous state have been established. These methods are recommended to other agencies investigating air contamination from combustion sources.

07077

W. L. Pritchard, C. E. Schumann, and C. W. Gruber

**PARTICULATE SAMPLING BY ADHESIVE-COATED MATERIALS (PROGRESS REPT. NO. 1).** (Cincinnati Division of Air Pollution Control, Ohio, Dept. of Safety). Oct. 1, 1965 83 pp.

Sampling from the atmosphere and from incinerator stacks of particles ranging in size from 20 to 100 microns was accomplished by using adhesive-coated paper. Of 38 adhesive-coated materials tested, one appears to be best suited for atmospheric and source (incinerator) sampling. No appreciable difference was found in the concentration of particles collected on equal diameter cylinders spaced several feet apart in a location isolated from localized interference. A screen, around the sample jar, will interfere with the particulate collection efficiency. The mean diameter of particulates captured by adhesive-coated materials on 3 inch diameter (approx.) cylinder ranged between 35 and 50 microns. The distribution of the captured particles exhibits the pattern usually associated with comminuted dusts. During a 30-day test period the number of particles, by color classification, was similar for a given location but varied between locations. The collection efficiency or the best material mounted on cylinders of various diameters increased as the diameter of the cylinder decreased. The theoretical target impingement efficiencies calculated for the 2-15/16 inch (7cm) diameter jar were rather low especially for smaller particles at low wind speeds. The theoretical target impingement efficiency would be increased by using a smaller diameter cylinder (3.5cm). The adjusted particle count from the 15 sec and 30 sec incinerator tests were higher than the 60 sec particle count indicating that the collection efficiency will decrease with time of exposure to the stack gases. The particulate loadings on adhesive tapes used in incinerator testing should be between 5 and 20 particles per square millimeter for microscopic counting error.

08257

Baum, Fritz, Inge Reichardt, and Wolfgang Steinbach

**SIMPLE MEASURING ARRANGEMENT FOR RECORDING HYDROCARBON CONTENT.** Staub (English translation), 27(6):16-19, June 1967. 11 refs. CFSTI: TT 67-51408/6 (HC\$2.00)

A method for using a batch-sampling gas-chromatograph with flameionization detector to record continuously the presence of hydrocarbons is described. Use of this measuring device is illustrated by several examples. Hydrocarbons are thermally ionized in a hydrogen flame in the flame-ionization detector. Flue gases of an oil stove with vaporization burner, flue gases of a medium-size waste incinerator, and automobile exhaust were measured. The hydrocarbon content of the flue gas of an oil stove only exceeded that of the air in the laboratory above a combustion rate of 0.5 kg of oil per hour. With decreasing chimney draft the hydrocarbon content of the flue gases rose sharply, being accompanied by an increase of the Bacharach soot number. When the chimney draft was throttled to 0.1 mm



W.G. at the maximum combustion rate, the concentration of hydrocarbons rose to 350 times the value of normal operation. The combustion phases in a medium size waste incinerator can be directly observed with the measuring device. Total hydrocarbon concentration in the exhaust of an automobile at various operating conditions is presented. In neutral, a slight increase in hydrocarbon concentration was recorded. During acceleration in neutral the concentration dropped immediately. The concentration varied when the position of the accelerator was changed. On a 14% grade, finally, the concentration dropped briefly and then rose considerably.

08675

Tuttle, W. N. and M. Feldstein

**GAS CHROMATOGRAPHIC ANALYSIS OF INCINERATOR REFLUENTS.** J. Air Pollution Control Assoc., 10(6):427-429, 467, Dec. 1960. 10 refs. (Presented at the 53rd Annual Meeting, Air Pollution Control Assoc., Cincinnati, Ohio, May 22-26, 1960.)

A procedure for the gas chromatography analysis of low molecular weight hydrocarbons present in incinerator effluents has been described and has been used to analyze the effluents from a series of incinerators. Results indicate that, when the concentration of C2 hydrocarbons is below 10 ppm, the C3 to C6 hydrocarbons are generally present in less than 1 to 2 ppm. When C2 hydrocarbons are present in high concentrations, the C4 to C6 compounds are generally present in significant concentrations. Some specific C4 to C6 compounds found in the effluents from incinerators have been identified. The standard of 50 ppm of C2 to C6 hydrocarbons in incinerator effluents appears to be a satisfactory emission standard since it adequately differentiates between incinerators which are well designed and operated and those which are not.

11088

Public Health Service, Washington, D. C., National Center for Air Pollution Control

**ADDENDUM TO SPECIFICATIONS FOR INCINERATOR TESTING AT FEDERAL FACILITIES.** Preprint, 31p., Dec. 1967.

Material is supplied as a supplement to the publication, 'Specifications for Incinerator Testing at Federal Facilities.' An alternative method for determining particulate emissions, which has the same stringency as the present method based on carbon dioxide measurements, but permits simpler, less expensive, sampling procedures, may be followed if tester so desires. To use the alternative method, tester must determine the pounds per hour of particulate emitted. In using the method, it is necessary only to sample for particulates and determine emissions in pounds per hour. It is necessary to measure carbon dioxide during test runs, or determine carbon dioxide emitted from burning auxiliary fuel. Whichever method for determining compliance is used, the general testing procedures detailed in 'Specifications for Incinerator Testing at Federal Facilities', and this Addendum will apply, with a specified modification.

14368

Marshall, A., G. Crawford, and M. Nolan

**CONVERSION FACTORS FOR SOURCE EMISSION MEASUREMENTS OF INCINERATOR FLUE GASES.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 176-179. 2 refs. (May 5-8).

Tighter air pollution codes have created a need for standardized procedures for expressing incinerator dustloading values. Dustloading is usually expressed in pounds of dust per 1000 pounds of flue gas or grains of dust per standard cu ft, where 7000 grains is equal to one pound. In any dustloading test, some of the variables which must be taken into consideration are the type of refuse or fuel being consumed, atmospheric conditions, such as temperature and pressure, and the components of the flue gas. The formulas presented in this paper take these variables into account, and additionally, certain assumptions and simplifications were made to make their derivation possible. A test method is described for measurement of the source emission weight from a specified amount of refuse burned in an incinerator, based on isokinetic sampling. A special slide rule was developed by the authors which greatly simplifies the use of the various formulas presented in the paper. The slide rule may be used to correct dustloading value to either a 50% excess air or 12% CO<sub>2</sub> basis. It may also be used for converting grains/cu ft to grains/std cu ft, as well as for converting grains/cu ft to lbs dust/1000 lbs flue gas and vice-versa, and for calculating the percentage of excess air in terms of the Orsat analysis of the flue gas.

15533

Romanek, Walter, Mary R. Jackson, and Alvin Lieberman

**PROTOTYPE FLY ASH MONITOR FOR INCINERATOR STACKS.** (Final Report). IIT Research Inst., Chicago, Ill., Technology Center, R-IITR-C8088-8, 145p., Sept. 25, 1968. CFSTI: PB 187393

A prototype monitor for particulate emissions from municipal incinerators was designed, built, and field tested. In operation, the instrument is installed on a stack some distance above the base to ensure the monitor's presence in a laminar flow region. The monitor samples a predetermined quantity of stack gas either isokinetically or at a known velocity, separates the particulate from the gas by means of a cyclone, and measures the amount of particulate collecting using a beta gauge. For each sample, the time of sampling and beta attenuation is printed out on a paper tape at a convenient ground level location. The design concept is suitable for unattended monitoring operations. Field tests show that the instrument measures stack dust loading under varying furnace operating and atmospheric conditions and that automatic isokinetic sampling, while feasible, is not an essential requirement for adequately following stack loading. (Author abstract modified)

17352

Levin, Harry

**NOTE ON A SLURRY METHOD OF PARTICLE INDUCTION.** J. Air Pollution Control Assoc., 20(3):178-179, March 1970.

As part of a program concerned with the incineration of solid waste to produce megawatt electric power, an alumina slurry method of inducing test particles into a high-temperature, high-pressure gaseous flow stream was developed. The slurry is prepared by adding alumina to gelled methanol and blending the mixture for several hours in a vibroenergy mill. This processing causes an effective dispersion of alumina particles. Commminution of particles is minimal because of the high velocity of the slurry and the comparable hardness of particles and milling medium. On demand and at prescribed flow rate, the slurry is delivered through metal tubing to the burner. Delivery is accomplished by a controlled and metered flow of methanol into the slurry cylinder above the piston and under pressure of nitrogen. Within the burner, the slurry is atomized, prior to injection, by injection into and impingement with



methanol streams. This method of test particle induction provides improved particle statistics through stable homogenization of particles in blending and removal of angularities from particles of interest in particle size distribution analyses. The method converts poor collections of particulate materials into highly useful test dusts.

17468

**SOURCES OF ATMOSPHERIC SULFUR DIOXIDES AND MEASUREMENT METHODS.** (Taikichu no iousankabutsu no hasseigen to sokuteihoho). Text in Japanese. Sangyo Kogai (Ind. Public Nuisance), 5(10):612-620, Oct. 25, 1969. 62 refs.

Atmospheric sulfur dioxide exists in various chemical and physical forms; under normal conditions, it is in a gaseous state containing some volatile sulfuric mist and sulfate. If gaseous sulfur dioxide were the only atmospheric pollutant, its measurement would not be so difficult. The existence of sulfuric mist and sulfate and other interfering substances in the atmosphere make analytical procedures intricate. Some difficulties in analytical assessment of atmospheric SO<sub>2</sub> are also correlated with the limits involved in technical methods, some of which, like the West-Gaeke or electroconductivity methods, are subject to error due to the existence of atmospheric interfering elements at variance with the substantial characteristics of SO<sub>2</sub>. Therefore, in evaluating measurements obtained from applied methods and laboratory techniques, allowance must be made for sequential and accidental errors. Atmospheric values obtained with the different methods are apt to vary. The widely used analytical procedure for SO<sub>2</sub> determination involves separating mist from sulfuric mist and measuring the sulfur in the sulfate contained in the air sample. The quantity of SO<sub>2</sub> is determined simultaneously with the measurement of suspended sulfate is an aerosol state or contained in dust fall. In 1965, the amount of sulfuric acid gas emitted to the atmosphere was 23,400,000 t. In 1966, the amount was 28,600,000 t of which 58.2% came from coal combustion in thermal power plants; 19.6%, from oil combustion; 5.5%, from petroleum refinery processes; 12.2%, from mine refinery processes; 1.9%, from sulfuric acid production; and the rest, 0.4%, from waste incineration. Various types of SO<sub>2</sub> analyzers, including currently improved U. S. models, are presented.

19580

Gruber, Charles W. and Charles E. Schumann

**THE USE OF ADHESIVE-COATED PAPER FOR ESTIMATING INCINERATOR PARTICULATE EMISSIONS.** J. Air Pollution Control Assoc., 12(8):376-378, Aug. 1962. (Presented at the Air Pollution Control Association Annual Meeting, 55th, Chicago, Ill., May 20-24, 1962.)

The reliability of using the 'number of particles per min' caught on adhesive paper as an indication of excessive incinerator emissions was investigated in tests of 14 incinerators with burning rates per hr of 25 to 1250 lb. In this method, strips of adhesive paper are wrapped around a glass jar that is then inserted into a stack for 30 sec. A minimum of three samples is collected: one at approximately one min after start-up, one midway through the burn-down, and another toward the end of burn-down. After the sample is collected, a two-in. square is cut from the adhesive and mounted on a slide for microscopic particle counting. From the average number of particles counted on random fields, the number of particles per sq in. is first calculated and then the number of particles per min. Test data show a close relationship between the adhesive-paper loadings and excessive emissions as indicated by citizen complaints.

20808

Klein, Nicholas and Yeshaye Levy

**SMOKE CLEANING APPARATUS.** (Assignee not given) U. S. Pat. 3,487,620. 6p., Jan 6, 1970. 15 refs. (Appl. Feb. 16, 1968, 1 claim).

Filter screens for removing solid particles from the smoke of incinerator stacks tend to become quickly clogged, reducing the draft required to operate the incinerator effectively. If clogging is to be avoided, the filter mesh is of such coarseness that an excessive amount of solid particles is discharged to the atmosphere. Apparatus is provided for washing the smoke in a draft of steam and draining off the condensed steam which contains the removed particles. The heat of combustion in the incinerator generates steam in a coiled, tubular heat exchanger continuously supplied with fresh water. Steam travels up the stack and impinges on a water-cooled moving screen which travels across the stack. The screen is scrubbed continuously and polluted water containing solid particles is drained off to a sewer. A disinfectant-deodorant, such as ozone, is volatilized in the heat exchanger and discharged with the steam into the smoke. In a modification of the invention, a two-stage smoke cleaning apparatus is provided. Cold water is discharged on a stationary conical screen which catches the solid particles in the smoke, while a field of finely divided streams of cold water is maintained across the stack. Any fine particles in the smoke passing through the streams are caught and carried away to a drain.

21663

Sandia Lab., Albuquerque, N. Mex.

**CONTROL OF AIRBORNE CONTAMINATION.** In: Contamination Control Handbook. NASA Order H-13245A, Section 5, 98p., 1969. 52 refs. CFSTI: NASA SP-5076

A detailed review of the facilities, equipment, and techniques for control of airborne contamination within a controlled environmental area is presented, with accompanying tabular summaries and diagrammatic illustrations. Contaminants are classified into major groups of organic and inorganic gases and aerosols, and major sources are noted. Control techniques are discussed in terms of devices for aerosols and gases, detection and measurement, and sampling. Types and selection criteria are given for air filters to be used in contamination control facilities, with a section on high-efficiency particulate filters. Nonlaminar airflow facilities (conventional clean rooms) are described, and the advantages and disadvantages of laminar airflow facilities outlined, with detailed descriptions of horizontal and vertical laminar airflow work stations. Temperature and humidity control, construction, furniture and equipment, and personnel garments for clean rooms are considered. A review of monitoring includes air sampling and collection methods, analytical methods and instrumentation, and filter bank leak testing. Specifications for laminar airflow clean rooms are considered at length.

23437

Peterson, Folke

**MEASUREMENT OF SOOT.** (Sottalsmatning). Text in Swedish. VVS(J. Assoc. Heating, Ventilation, Sanit. Engrs.) (Stockholm), 60(11): 597-606, Nov. 1969.

The Bacharach number is an indirect determination of the content of solids in fuel oil. For heavy fuel oils, no direct correlation exists between Bacharach number and solid content. For solid fuels or waste incineration, the correlation is even less distinct, and the Bacharach number is not useful. The errors involved in a correctly determined Bacharach number are slight. A 5% change in the volume of flue gas will not normally influence the number.

24412

Rowe, D. R. and L. W. Canter

**AIR POLLUTION: CAUSES, EFFECTS AND RESOLUTION.** Public Works, 101(10):86-87, Oct. 1970.

Various modes of transportation account for 60% of the total pollutants, industry for 19%, generation of electricity for 12%, space heating for 6%, and refuse disposal for 3%. These pollutants can be classified as primary or secondary, i.e., those emitted directly into the atmosphere and those formed by reactions occurring in the atmosphere, or they can be classified as particulate or gaseous. Settling particulate matter can be easily determined with a dust fall bucket, suspended particulates with a Hi-Vol sampler, and their soiling index with a paper tape sampler. Monitoring gases is more complicated, though simple detector tubes with specific color changes can be used to determine whether a serious ambient air quality problem exists. The sun plays a major role in the production of secondary pollutants and of photochemical smog. Meteorology is also of prime importance in air pollution and has many applications in air pollution control such as plant-site location, city planning, zoning, stack height, and allowable emission rates. Conversely, air pollution can affect meteorological conditions, reducing visibility and solar radiation and increasing fog and precipitation. Control of air pollution requires establishment of air pollution criteria and air quality standards, followed by ambient air quality standards for particulates, gases, and odors and emission standards.

Along with these steps must go enforcement, either by policing, tax incentives or a charge for using air.

25696

Feldstein, Milton

**STUDIES ON THE ANALYSIS OF HYDROCARBONS FROM INCINERATOR EFFLUENTS WITH A COMBUSTIBLE GAS INDICATOR.** Am. Ind. Hyg. Assoc. J., vol. 22:286-291, Aug. 1961. 4 refs. (Presented at the American Industrial Hygiene Association, 22nd Annual Meeting, Detroit, Mich., April 1961.)

A combustible gas indicator with a 10 to 1 sensitivity scale was studied in relation to the measurement of C2 and higher hydrocarbons from incinerator effluents. Samples were collected in evacuated stainless steel 34-liter tanks over a 15-minute period. The instrument was modified in that the drying agent was replaced with ascarite, and a small diaphragm pump was substituted for the rubber aspirator bulb. Response to carbon monoxide and hydrocarbons was differentiated by means of a tube of activated carbon which adsorbed hydrocarbons, but did not adsorb carbon monoxide or methane. The instrument can be used to differentiate between incinerators emitting less than 50 ppm total hydrocarbons, and those emitting higher concentrations of hydrocarbons. Precautions to be observed in the use of the instrument for the measurement of C2 and higher hydrocarbons are discussed. (Author summary)



## D. AIR QUALITY MEASUREMENTS

00149

J. F. Clarke, and R. B. Faoro

**AN EVALUATION OF CO<sub>2</sub> MEASUREMENTS AS AN INDICATOR OF AIR POLLUTION.** J. Air Pollution Control Assoc. 16, (4) 212-8, Apr. 1966.

Measurements of ambient CO<sub>2</sub>, made at the Continuous Air a rural location near Cincinnati are presented and evaluated to determine the significance of CO<sub>2</sub> data in urban air quality monitoring programs. Through analysis of rural CO<sub>2</sub> data and evaluation of combustion sources by means of a diffusion model, it is demonstrated that the variation of urban CO<sub>2</sub> concentrations around the prevailing atmosphere background level results from combustion and noncombustion (natural) sources. The concentration from natural sources can be substantial and in fact override the combustion sources. Because it is not yet practical to predict the contribution of natural sources to urban CO<sub>2</sub> concentrations, data obtained for this gas have only limited utility as an index of air quality. Significant statistical relationships between CO<sub>2</sub> data and air quality measurements for summer months are shown to result from similar meteorological effects rather than similar sources. A seasonal and spatial variation of these relationships is postulated and subsequently demonstrated by analysis of CO<sub>2</sub> and air quality measurements from New Orleans, Louisiana, and St. Louis, Missouri (Author)

02395

E. R. Kaiser.

**CHEMICAL ANALYSES OF REFUSE COMPONENTS.** Proc. Natl. Incinerator Conf. 84-8, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

The proximate and ultimate analyses of 20 constituents of municipal and commercial refuse are presented, together with the calorific values. The analyses are useful to incinerator engineers as they are the basis for calculating air requirements, flue-gas volumes, and heat and material balances. The analyses of components of refuse permit the calculation of composite analyses of mixed refuse from known proportions. Future investigations are suggested to obtain more complete refuse data and to determine the variability of municipal refuse. (Author abstract)

02833

**AIR POLLUTION IN ERIE COUNTY (COMPREHENSIVE AREA SURVEY REPORT NUMBER TWO.)** New York State Air Pollution Control Board, Albany. 1963. 109 pp.

The objectives of this survey were: To determine, by means of a contaminant emission inventory, the relative contribution of the respective sources of air contamination to the overall loading of the community atmosphere. To determine population, land use, agriculture and industrial development trends and the ability of the air reservoir to dilute and disperse air contaminant emissions. To extrapolate, from applicable meteorological, air sampling and source data, the potential atmospheric concentrations of the more common air contami-

nants. To assess the effectiveness of presently applied emission controls and the administrative steps that have been and can be taken by government agencies to control both existing and potential air pollution sources.

03454

W. C. Cope, Chairman.

**SMOKE AND AIR POLLUTION - NEW YORK - NEW JERSEY.** Interstate Sanitation Commission, New York City. Feb. 1958, 95 pp.

Pollution in the metropolitan area was studied by: aerial reconnaissance and photography; and surveys in the communities. Significant information was collected on: relationships of meteorology, visibility and pollution; interstate movement of pollution as indicated by releasing tracer dust in one state and collecting in the other; amount of vehicle exhaust fumes and other organic materials in the air; sulfur dioxide concentration on Staten Island, and ozone on Staten Island and in Carteret, N.J.; effects of the polluted atmosphere on health, vegetation, materials and transportation; and a study and evaluation was made of existing laws in the State of New York, New Jersey and Connecticut, and other jurisdictions. Air pollution originating in regions of New York and New Jersey within the New York Metropolitan Area is interstate in character, affects public health and comfort adversely, and damages property. While the control and abatement of air pollution at its sources is the primary obligation of the states, counties or municipalities in which it originates, the problems of interstate air pollution cannot be solved wholly by governmental agencies independently of one another. The abatement of existing interstate air pollution and the control of future interstate air pollution is of prime importance to the persons living and industry located in the area affected thereby, and can best be accomplished through the cooperation of the states involved, by and through a common agency or instrumentality. An interstate instrumentality, employing the administrative practices followed by the Interstate Sanitation Commission in the abatement of interstate water pollution, should be created to deal with the problems of interstate air pollution. Drafts of proposed legislation to meet the situation described in this report should reflect fully the opinions and needs of many agencies, local governing bodies, members of the Legislatures, representatives of industry, and of the public. There has been insufficient time between the completion of the study and the submission of this report to afford opportunity to interested agencies to express their views on the form which legislation to abate interstate air pollution should take.

22812

Wohlers, H. C. and G. B. Bell

**LITERATURE REVIEW OF METROPOLITAN AIR POLLUTANT CONCENTRATIONS- PREPARATION, SAMPLING AND ASSAY OF SYNTHETIC ATMOSPHERES. (FINAL REPORT).** Stanford Research Inst., Menlo Park, Calif., Contract DA 18-064-404-CML-123, S.R.I. Proj. SU-1816, 193p., Nov. 30, 1956. 82 refs.

A literature review of metropolitan air pollutant concentrations and of the preparation, sampling, and assay of synthetic atmospheres is presented. Measured concentrations of gaseous and particulate pollutants in the atmosphere, including sulfur dioxide, hydrogen sulfide, nitrogen dioxide, ammonia, formaldehyde, hydrocarbons, chloride, carbon monoxide, ozone, fluoride, hydrogen fluoride, carbon dioxide, gross particulates, and dust fall are tabulated. Calculated emissions from centers of population are presented for industrial and public processes, including combustion of coal, oil, and natural gas, incinerators, automobile exhausts, power plants, and metallur-

gical operations. Data on measured and calculated air pollution concentrations throughout the world are given. Methods for injecting pollution simulants into a test chamber, such as ozone generators and aerosol dispensers, are mentioned. Sampling and analytical procedures are described for the particular problem of testing static atmospheres for bacteria. Sampling equipment consists primarily of an impinger preceded by a millipore filter. Analytical procedures include ultraviolet absorption, high volume sampling, glass fiber filters, and colorimetric, gravimetric, iodimetric, spectrophotometric, Saltzman, and electrochemical methods.

## F. BASIC SCIENCE AND TECHNOLOGY

01798

B.D. Tebbens, J.F. Thomas, M. Mukai

**PARTICULATE AIR POLLUTANTS RESULTING FROM COMBUSTION.** Am. Soc. Testing Mater., Spec. Tech. Publ. 352. (Presented at the Symposium on Air-Pollution Measurement Methods, Los Angeles, Calif., Oct. 5, 1962.) pp 3-31, Dec. 1963.

An enormous variety of organic by-products result from both oxidative degradation of fuels and synthesis of complex molecular species occurring simultaneously when combustion is incomplete. Synthesis is demonstrated by the fact that polynuclear aromatic hydrocarbons with molecular weights up to 300 may be derived from incomplete combustion of such a simple fuel as methane. These hydrocarbons are part of the solid phase of combustion by-products and may be filtered from gaseous components. Among them are the arenes naphthalene, anthracene, pyrene, benzo(a)pyrene, dibenz(a,h)anthracene, and others. Additionally, there exist relatively non-volatile oxidation derivatives such as alpha- and beta-naphthol and others. Only a few of the 90 or more individual chemical entities found in these series have been positively identified. Sufficient evidence exists from burning a variety of gaseous, liquid, and solid fuels to state categorically that it is the process of combustion rather than the chemical quality of the fuel which leads to synthesis of these arenes. Fuels studied include natural gas; propane; butane; 1-butene; 1,3-butadiene; ethyne, hexane; 2,2,4 trimethylpentane cyclohexane; 1-hexene; benzene; toluene; and gasoline, as well as the miscellaneous celluloses involved in incineration of paper, wood, tree trimmings, and the like. The same range of aromatic hydrocarbons has been separated from contaminated air in distressed urban atmospheres. Investigation of aldehydes produced by combustion indicated that only formaldehyde decreased with increasing secondary air when combustion was incomplete. However, with complete combustion, use of additional secondary air was accompanied by an increasing quantity of formaldehyde. Thus using large excesses of secondary air to control smoke may be inadvisable for air-pollution control. The total amount of arenes produced depends in part on the incompleteness of the burning process. While one would assume that the smoking point of fuels would be an index of relative ease of combustion and of relative desirability of fuels for urban usage, the possible production of combustion nuclei is also suggested. Such a criterion may become significant in choosing fuels suitable for use in urban environments. (Author summary modified)

09284

Stumbar, James P. and Robert H. Essenhigh

**FLAME SPREAD DOWN PAPER CYLINDERS.** Preprint, Pennsylvania State Univ., University Park, Dept. of Fuel Science, 4p., 1967. (Presented at Eastern States Section Meet-

ing, Combustion Institute, Pittsburgh, Pa., Nov. 27-28, 1967.)

The rate of flame spread down vertical paper cylinders has been measured to provide information on the rates and mechanisms of flame spread on a material representative of typical wastes, for prediction of transient behavior in a test incinerator. The cylinder diameters ranged from 1/8 in. to about 2-1/2 in. The rates of spread were in the range 0.05 in./sec. to 0.2 in./sec., and were found to be a prime function of diameter. As the diameter increased from 1/8 in., the rate initially fell, but it soon reached a minimum (at about 1/4 in. dia.) and then started to rise again. After going through a point of inflection it continued to rise but tending to an upper limit. This general behavior, expressible by an equation quoted, was found to be obeyed when the cylinder bottom was either open or closed (plugged with a stopper), and also at two different levels of humidity.

13618

Reh, L.

**FLUIDIZED BED INCINERATION.** (Verbrennung in der Wirbelschicht.) Translated from German. Chem. Ing. Tech. 40(11):509-515, 1968. 12 refs.

The use of fluidized bed incineration is limited, among other things, by the combustion temperature, the calorific value of the fuel and the gas velocity in the turbulent layer. By adequately controlling the combustion process a very narrow temperature range can be maintained, which is demonstrated by various examples (roasting of sulfide ores at various types of cooling, regeneration of pickling bath, incineration of oil and waste sludge).

14370

Satyanarayana Rao, T. R., G. Gelernter, and R. H. Essenhigh  
**SCALE UP OF COMBUSTION POT BEHAVIOR BY DIMENSIONAL ANALYSIS.** American Society of Mechanical Engineers, New York, Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 232-236. 3 refs. (May 5-8).

The nature is established of dimensionless groups characterizing combustion behavior in an incinerator. In particular, these groups should determine the influence of scale in transposing results from the combustion pot to the incinerator. The analysis indicates that if  $F(A)$  is the burning rate per unit area of grate and  $k$  is an effective reactivity coefficient, then the ratio  $(F(A)/k)$  can be expressed as a function of a minimum of four groups involving nine parameters. From inspection of these groups, it would seem that their values may well be the same in both systems for the same range of dimensional parameters in the two systems. It follows from this that the scale factor involved should be unity, i.e., combustion and burning rate data obtained in a combustion pot should transpose to an incinerator bed without change. For other things then being equal, the area burning rate can only be increased if  $k$  is increased. (Author abstract modified)



## G. EFFECTS-HUMAN HEALTH

01941

M. B. Jacobs

**HEALTH ASPECTS OF AIR POLLUTION FROM INCINERATORS.** Proc. Natl. Incinerator Conf., New York, 1964. pp. 128-31.

The public health aspects of incinerator exhaust gases are discussed first in the light of the physiological response induced by specific contaminants such as sulfur oxides, nitrogen oxides, and other inorganic gases and aldehydes, organic acids, esters, polynuclear hydrocarbons, and other organic compounds; second, with respect to their relation to illness caused by air pollution in general such as emphysema and other respiratory diseases, allergenic responses, and cancer; and third on the character of the effluent gases, namely domestic, municipal, or industrial. One aspect of domestic incinerator effluents is particularly stressed, that is, the effect on nearby residents. The contribution that incinerator exhaust gases make to the air pollution of any given community depends on the ratio of the amount of refuse and garbage burned to the total amount of fuel used and consumed in that region.

23167

Gilluly, Richard H.

**THE HAZARDS OF TRACE ELEMENTS.** Sci. News, 97(23):560-561, June 6, 1970.

When researchers at a metal-free laboratory at Brattleboro, Vt., exposed rats and mice orally over their lifetimes to environmental amounts of all the elements found in the National Air Sampling Stations, three elements appeared of concern in the amounts found in the environment: lead, nickel, and cadmium. In doses comparable to amounts that might accumulate in humans living near dense traffic, lead shortened life spans of the experimental animals and caused nervous system deterioration. Nickel carbonyl results from a reaction between nickel and hot carbon monoxide which probably takes place in incinerators and in internal combustion engines. It is absorbed

by the lungs and is probably carcinogenic. Inhaled, cadmium can cause emphysema and bronchitis. Taken into the body, through the lungs or otherwise, it is associated with cardiovascular death rates, hypertension, and kidney disease. Vanadium alone is nontoxic in laboratory animals in amounts far larger than found in the environment, but it may facilitate creation of enough sulfur trioxide to cause problems. However, adequate chromium in the diets of experimental rats will prevent the toxic effects of lead. An approach that has been suggested to deal with trace elements in water supplies is to create dual water-supply systems, one system for industrial uses and residential uses and the second for drinking water.

23793

World Meteorological Organization, Geneva, Switzerland and International Society for Biometeorology

**A SURVEY OF HUMAN BIOMETEOROLOGY.** TN-65, WMO-160.TP.78, 113p., 1964. 220 refs.

Human biometeorology studies the influences of the meteorological elements such as temperature, humidity, wind, radiation, and atmospheric electricity on man in health and in disease, his adaptability to changes in the environment, and the use of weather and change of climate in the treatment of human disease. Homeostatic mechanisms such as the nervous system and endocrine system are discussed in terms of adaptability. The influences of various meteorological parameters on human functions are studied. The influences of trace elements are considered. Sources and effects of various pollutants are listed, including fuel combustion, incineration, and automobiles, producing particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, ozone and other oxidants. The effects of the influences of weather on diseases are tabulated. Drug effects, reaction speed, working efficiency, and accidents are all influenced by climate. The effects of town planning on the microclimatic environment of man are discussed. Farm animals and insects can be affected by climate, and in turn, they can affect man. The therapeutic utilization of climate is described. (Author summary modified)

## H. EFFECTS-PLANTS AND LIVESTOCK

09275

Bohne, Helmut

**IMMISSION DAMAGE CAUSED BY HOSPITAL WASTE INCINERATION.** STAUB (English translation), 27(10):28-31, Oct. 1967. 4 refs. CFSTI: TT 67-51408/10

The strong decolorization and whitening of plants observed in

two gardening nurseries were caused by hydrogen chloride. In both cases the sources of emission were refuse incineration plants of hospitals in which chlorine compounds in the refuse, consisting 80- 90 percent of paper and packaging material, were decomposed during short periods at a temperature of 800 1,000 deg C. Erection of chlorine washing plants appears, therefore, to be necessary. (Author's summary)

## I. EFFECTS-MATERIALS

12055

Nowak, F.

**CORROSION PROBLEMS IN INCINERATORS.** Combustion, 40(5):32-40, Nov. 1968.

The state of the art of corrosion in incinerators is reviewed. While at first glance there seems to be no great difference between an incinerator whose generated heat is being used for steam generation and a boiler fired with conventional fuel, in fact many more problems are encountered due to the heavy deposits, more frequent outages, and gas-side corrosion of heating surfaces. Due to the nonhomogeneous nature of the waste materials and the corrosive components in the flue gas which are steadily increasing with the increase in plastics and other industrial wastes fired, control of conditions in incinerators is difficult. Some examples of corrosive experience and some approaches to control of the problems are discussed.

14737

Faessler, K., H. Leib, and H. Spaehn

**CORROSION IN REFUSE INCINERATION PLANTS.** (Korrosionen an Muellverbrennungskesseln). Text in German. Mitt. Ver. Grosskesselbesitzer, 48(2):126-139, April 1968. 57 refs.

The state of the boiler furnace of a refuse incineration plant after 42,000 hours of operation is described. Despite a rather high HCl content in the flue gas, no extreme corrosion was found on the boiler tubes (maximum wall temperature 350 C). Points of high flue gas turbulence (which prevents incrustation) showed greater corrosion, but this occurred only at the transition from furnace to boiler. The pipe incrustations from various parts of the furnace were analyzed by chemical and X-ray fluorescence and X-ray fine structure methods. Microprobe measurements were also taken. The results showed that chlorides and sulfates are present in sufficient quantities to trigger and sustain chloride or sulfate corrosion processes. It was determined from a review of the literature that only at pipe wall temperatures greater than 400 C is there any heavy corrosion. Corrosion occurs at this point because the pipe incrustations begin to melt at these high temperatures.

16420

Rasch, Rudolf

**REFUSE INCINERATION AND SYNTHETIC PACKING MATERIAL.** (Muellverbrennung und Kunststoffverpackung). Text in German. Verpackungs Rundschau, 19(10):67-73, 1968. (Presented at the 23rd Arbeitstagung des Instituts fuer Lebensmitteltechnologie und Verpackung, Munich, April 3, 1968.)

The per capita accumulation of refuse per year is about 200 to 240 kg. The specific weight can be as high as 600 kg/cu m (at high ash content) or as low as 200 kg/cu m (at a high amount of packing material). The annual volume per capita ranges from 0.4 to 1.2 cu m. Common disposal methods are sanitary landfills, composting, and incineration, the latter being the safest and most hygienic method. Flue gases resulting from

this process must be cooled to 250 C for cleaning. Incineration of synthetic packing material, such as polyvinyl chloride can lead to corrosion due to hydrogen chloride formation. The flue gases of the average incinerator contain 0.1 to 0.2% HCl. Corrosion can be prevented by neutralizing the flue gas, using excess air, and limiting superheater temperature. In coming years, the PVC fraction among refuse will increase to about 2% by weight. With the measures outlined, corrosion can be held within limits. If the polyvinyl chloride fraction, however, exceeds 5%, the danger of corrosion will be real.

19325

Konda, Kiyoshi, Hisao Ito, and Atsuhiko Honda

**FIELD EVALUATION OF EXHAUST GAS FROM REFUSE INCINERATOR RELATED TO AIR POLLUTION AND METAL CORROSION.** Trans. Soc. Heating, Air-Conditioning, and Sanitary Engrs. (Japan), vol. 7:95-104, 1969.

A study of municipal incinerator exhaust gas composition conducted at five sites in Japan is described. The study was undertaken to obtain information on odor and metal corrosion problems. The exhaust consisted of sulfur oxides, nitrogen oxides, ammonia, sulfuric acid, nitric acid, organic acids, and hydrochloric acid. Volatile organic acids and hydrochloric acid are mainly responsible for the corrosion, with sulfuric and nitric acids only partially concerned. Percentages of exhaust products as a function of raw refuse input are tabulated. Continuous firing rather than batch firing would limit noxious effluents. Temperature and excess air control would also help. After-burning chambers should be installed to further reduce contaminants.

24187

**MAINTENANCE OF ODOR-CONTROL SYSTEMS.** Environ. Control Safety Management, 1970:58-59, Oct. 1970.

Material failures in odor control systems can do more than result in costly downtime for maintenance, repair, or replacement of plant equipment. While not harmful to health, odor is annoying and can affect community relations. To prevent odor during fermentation from being vented into the atmosphere, engineers at a pharmaceutical company producing antibiotics devised a system for conducting the fumes of the fermentation facilities to the power plant for incineration. They discovered, however, that the system's fans and ductwork were subjected to moderately heavy pitting and corrosion, which resulted from warm moist particulate matter being picked up from the fermenting tanks and carried in the airstream. The first step in controlling the old system was to specify a more corrosion-resistant material for the ductwork and fans. Type 316 stainless steel was specified, containing 16-18% chromium, 10-14% nickel, and 2-3% molybdenum. The replacement ducts were made from 16-gauge stainless steel sheet, and four-foot-long duct sections were butt-welded together into eight-foot lengths. These longer sections were joined during installation with simple flanged joints sealed with a silicone material.



## J. EFFECTS-ECONOMIC

01294

C. A. Rogus

**EUROPEAN DEVELOPMENTS IN REFUSE INCINERATION.** Public Works 97, (5) 113-7, May 1966.

The major overall trends observed in Europe's incinerators are the following: a) There are fewer but larger central incinerators with progressively larger furnaces, up to 500 TPD each. b) Typical installations use rugged grates of designs providing continuous, mild mixing and agitation of burning refuse. c) Furnace chambers are high roofed. d) Use of water cooled walls and arches is widespread. e) Many waste heat boilers with steam and power generation are installed. There are some indications that this trend may not continue should the natural gas resources recently opened in the Netherlands be made economically available in Central Europe. f) Raw gas cleansing is performed by electrostatic precipitation. g) There is ever increasing use of automation and mechanization, and an attendant dependence on more sophisticated instrumentation. h) Fewer (one or two per plant) but much higher exhaust stacks of monolithic reinforced concrete construction are customary. i) Shredding of oversized wastes permits incineration of these articles with normal refuse. (Author summary)

02392

J. A. Fife and R. H. Boyer, Jr.

**WHAT PRICE INCINERATION AIR POLLUTION CONTROL?** Proc. Natl. Incinerator Conf. 89-96, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

This paper takes an objective but statistical approach to seventeen possible combinations of air pollution control equipment for municipal incinerators. Both refractory-lined and water-walled furnaces of identical capacities are followed by gas tempering systems, where required, and thence to mechanical cyclones, electrostatic precipitators, or bag filters. Additional alternates include the introduction of furnace gases directly to either a refractory-lined baffled spray chamber or to a wet scrubbing system. Thus, each furnace unit is equipped with a separate and independent air pollution control system. Empirical latitude applies in certain design areas, but experience is combined to draw conclusions. Thus, assessment of capital and operating costs of incinerator air pollution control equipment indicates several entirely possible solutions to a universally acknowledged problem. (Author abstract)

03006

**MODERNIZATION OF THE CITY INCINERATOR PLANT (ENGINEERING REPT. TO THE CITY OF KENOSHA, WISCONSIN).** Consoer, Townsend and Associates, Chicago, Ill. Nov. 1966. 45 pp.

This report includes a number of studies considered the most economical and efficient for modernization of the city in-

cinerator plant. It is recommended that the four existing incinerator units be remodeled by (1) installing modern reciprocating type of multiple arm rocker grate type stokers, and (2) combining the two pairs of existing units into two larger units to obtain the necessary length and volume of furnace and combustion chambers to incinerate mixed refuse. This will provide two incinerator units of approximately 15% of present plant capacity and permit burning a mixture of garbage and rubbish. The estimated cost of the recommended changes is also given.

11114

Ernst and Ernst, Washington, D. C.

**A COST-EFFECTIVENESS STUDY OF PARTICULATE AND SOX EMISSION CONTROL IN THE NEW YORK METROPOLITAN AREA.** Preprint, ((28))p., 1968. (Presented at the Air Pollution Abatement Conference, New York, N. Y. Feb. 1968.)

The annual cost of alternative methods for reducing particulate and SOx emission from power plants, stationary combustion sources, and incinerators is estimated. The alternatives include changing types of fuel and installation of various pieces of control equipment.

11857

Boubel, Richard W.

**A MODIFIED STATISTICAL 'TRANSPORTATION PROBLEM' AS APPLIED TO AN ATMOSPHERIC WASTE DISPOSAL EVALUATION.** Preprint, Air Pollution Control Association, New York City, 10p., 1965. 12 refs. (Presented at the Air Pollution Control Association, Annual Meeting, 58th, Toronto, Canada, June 20-24, 1965, Paper 65-161.)

In Oregon, residue from lumber and plywood manufacturing is usually incinerated in tepee burners. Since the particulate emission for a typical burner is about 30 pounds of aerosols per ton of fuels consumed, the burners present serious air pollution problems, particularly for Bear Valley where radiation inversions are common, resulting in a stable air condition with poor pollution dispersal. A preliminary cost study was made of the feasibility of alternate means of residue disposal in the valley, either using multiple chamber incineration facilities or power generation. The analysis, which used a constant cost figure for transportation of the residue from mill sites to disposal facilities, indicated that the cost of either method would be prohibitive. Transportation was a large item in the cost analysis. To reduce transportation costs, it will be necessary to optimize the number and location of disposal facilities. Related to the transportation problem was the location problem, i.e., distributing a combination of facilities throughout an area to minimize the costs of construction and expenses incurred in transporting resources to these facilities from predetermined source points. If burners were eliminated by authorities, the successful solution of this problem would enable mill owners to minimize disposal costs.

## K. STANDARDS AND CRITERIA

05197

A. J. Benline, and R. A. Wolff

**CRITERIA USED IN THE EXAMINATION OF APPLICATIONS FOR PERMITS TO INSTALL FLUE FED INCINERATORS IN THE CITY OF NEW YORK.** New York City Dept. of Air Pollution Control. Mar. 1962. 35 pp.

Since the creation of the Department of Air Pollution Control as a separate agency of the New York City government, the engineers of the Department have been examining applications and plans for many kinds of installations of fuel and refuse burning equipment at a rate of more than 800 per month. Prominent among these applications are those for the installation of flue fed incinerators. The purpose of plan examination is to make certain that well designed installations are made. While these Criteria were developed originally for the guidance of department engineers, they are now being published for the information of architects, engineers, installers, and others who are required to file plans with this Department. These are the Criteria the Department uses in examining applications. They are based on over ten years of intensive experience with many installations as well as the recommendations and standards of the Incinerator Institute of America, National Board of Fire Underwriters, Air Pollution Control Association, engineering textbooks, the catalogues, and brochures of contractors and manufacturers, the Rules and Regulations of the New York City Department of Air Pollution Control and the rules of other similar regulatory bodies. Improvements in the art of burning refuse efficiently, effectively, and without nuisance are under continuing development. In order to preclude prohibition of meritorious improvements not in compliance with these Criteria, the Commissioner may consider alternate designs. From time to time the Criteria will be reviewed and may be revised. These Criteria are necessary for the protection of the public in general and the purchaser of equipment in particular so that nuisances are not created nor illegal installations made.

07595

New York City Dept. of Air Pollution Control

**CRITERIA USED FOR UPGRADING EXISTING APARTMENT HOUSE INCINERATORS IN THE CITY OF NEW YORK.** 21p., Jan. 1967.

It is estimated that there are more than 17,000 apartment house incinerators operating currently in New York City. More than 75% of these were installed prior to the establishment of the Department of Air Pollution Control in 1950. Apartment house incinerators were then generally designed to fit into limited space without consideration of particulate emission control. The shortcomings can in most cases be overcome by modifications in design and a suitable particulate emission control device. The requirements for upgrading existing apartment house incinerators are outlined.

12118

Goder, Richard

**WHAT ARE STANDARDS FOR THE INCINERATOR INDUSTRY?** Preprint, 13p., June 1963. 9 refs.

The role of the incinerator industry in bearing responsibility for continuous development of incinerator design is discussed. A project is described in which three different standard incinerators, complying with the code specifications of the Incinerator Institute of America (IIA), Los Angeles County, and New York City, respectively, were tested by procedures outlined in A.S.M.E. Test Codes. Design and performance showed wide variation among the three units. There was considerable latitude in incinerator design to meet a specified performance, and it was apparent from the tests that the IIA design standards will safely meet the limitations required by most American cities to assure proper performance. Little progress in proper design of incinerators for refuse disposal can be made until a universal agreement on test standards, procedures, and instrumentation is adopted by air pollution officials and the industry.

14366

Cross, F. L., Jr. and R. W. Ross

**EFFLUENT WATER FROM INCINERATOR FLUE-GAS SCRUBBERS.** American Society of Mechanical Engineers New York Incinerator Div., Proc. Natl. Incinerator Conf., New York, 1968, p. 69-72. 6 refs. (May 5-8).

Florida's new air pollution control standards for incinerator emissions has focused attention on the use of dry control methods, such as bag houses or electrostatic precipitators to replace the conventional wet-scrubbing systems now used in large municipal incinerators. Although wet scrubbers reduce emissions to 0.1 0.2 g/cu ft, dry control methods can reduce these limits even further. Other problems caused by the use of scrubbers on incinerators involve high corrosivity of the scrubber effluent and inability of the effluent to meet Florida's criteria for water pollution control. In order to meet water quality standards, scrubber water must be treated to neutralize excess acidity and to remove chemical constituents before it can be released to a receiving stream or lake. Analyses of scrubber water at various installations showed a marked increase in chemical constituents in effluent over amounts found in raw water pumped from wells to supply the air pollution devices at the incinerator. Phenols and cyanide showed the largest increase in proportion to the amount found in the raw water, while aluminum, barium, chromium, copper, iron, lead, manganese, and zinc all showed increases over the raw water counts. It is suggested that the cost of dry control methods may not be as high as scrubber waste water treatment.

17201

Hishida, Kazuo

**EXPLANATION WITH GUIDES OF COLLECTOR FOR REFUSE INCINERATOR SMOKE.** (Gomi shyokyakuro no baien shori shisetsu shido hyojun no kaisetsu). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 3(6):365-372, June 15, 1967.

It is impossible to standardize measures to control incinerator smoke because incinerators are so diversified. For this reason, the Tokyo Metropolitan Environment Planning Office, Air Pollution Control Section, has issued a guide to refuse incinerator



smoke collectors, which will enable plants to select or decide on incinerators which are economical but meet operating criteria, or to improve existing units. The choice of an incinerator depends largely on the kinds of refuse burned and the required capacity. In addition, there are many regulations governing stack smoke. The property of smoke dust is determined by incinerator type, operation method, incineration condition, and kinds of refuse. For instance, when refuse bulk exceeds maximum capacity, half burnt ashes contain toxic gases or an unusual high temperature is registered inside the incinerator. Also, the collector becomes overheated. Incineration capacity is generally decided by operating conditions, which are as a rule subordinate to both regulatory acts and maintenance management. Good maintenance requires that inside temperature be kept at 1000 C during operation and that surfaces of metal fittings be kept at 200 to 350 C. In the case of batch incinerators, refuse should be introduced in spaced intervals and in small quantities. By preventing temperatures from dropping, this technique should improve combustion. Refuse incineration becomes more important as living standards increase. Consequently, advanced methods of condensing wet refuse and sorting refuse before incineration should be exploited.

22375

Voelker, Edward M.

**INCINERATOR STANDARDS.** J. Air Pollution Control Assoc., 12(10): 487-491, Oct. 1962. (Presented at the Air Pollution Control Association, 55th Annual Meeting, Chicago, Ill., May 20-24, 1962.)

The Incinerator Institute of America, a non-profit organization formed in 1950, has established standards with the aim to upgrade the services and products of their industry to meet the demand for efficient nuisance free disposal of combustible waste. If the space around the incinerator is inadequate, if there is insufficient air supply to the incinerator room, or if the stack or draft producing equipment is inadequate, then the best designed incinerator will not operate nuisance free. As the Incinerator Standards have purposely dealt only with basic incinerator designs, the designing architect and engineer are asked to give careful consideration to the following: collection and method of changing the refuse; ample areas for charging, stoking, and ash handling, as well as general maintenance; adequate air supply; the effect which any air conditioning or ventilating equipment may have on the air supply; adequate draft to assure safe operation and complete combustion at

reasonable temperatures; location of the top of the chimney or stack; immediate environments and the use of auxiliary equipment such as fly ash collectors; and current local codes and ordinances. Methods for determining the products of combustion from the burning of refuse are described: one procedure is to calculate the amount of theoretical and excess air based on ash and moisture free combustibles; the other method is to figure the theoretical and excess air requirements from the ash and moisture free combustibles, figuring separately the lb of dry gas, and to multiply to obtain the volume of dry gas. Water is figured separately and multiplied by the specific volume of water vapor at the temperature desired, and all the volumes are added together for a total figure. Cost considerations for incinerator design are also discussed.

22389

VDI (Verein Deutscher Ingenieure) Kommission Reinhaltung der Luft, Duesseldorf, Germany

**DISCHARGE LIMITATION FOR REFUSE INCINERATORS.** (FWDP 12). APPENDIX C. Preprint, 16p., 1965. 38 refs. Translated from German. Belov and Associates, Denver, Colo., 25p., Feb. 1970.

A provisional standard is provided for refuse incineration which includes descriptions of various types of incineration plants. Median values and typical characteristics for incineration are given for different kinds of refuse. Heating values, chemical contents of refuse, loads on grate areas, temperatures, and related parameters are included in the tabular presentation. The reduction of dusts from the combustion gas is treated with regards to what types of operations, mechanisms, actions, or abuses would contribute to the decrease or the increase in the formation of dust particles. The subject is examined according to fuel and fuel utilization, grate construction, burner space, air draft from below for pre-drying, secondary aeration, successive heating areas, funnel for flying dust, and cleaning installations. Various suggestions are offered in choosing between cyclones, electrical dust removers and other dust collectors. The construction and the efficiency of the burner installation, fuel and refuse characteristics, amount and granulation and characteristics of coarse dust, and available space for the dust remover must be known in order to make the choice. Typical values of removal efficiency are given for different removal systems and are tabulated according to the required draft pressure and location of use in the incineration facility. In addition, diverse factors that contribute to favorable and unfavorable degrees of dust separation in removers are listed, and some suggestions for the reduction of emissions are given.



## L. LEGAL AND ADMINISTRATIVE

00973

**A COMPILATION OF SELECTED AIR POLLUTION EMISSION CONTROL REGULATIONS AND ORDINANCES. (REVISED EDITION.)** Public Health Service, Washington, D.C., National Center for Air Pollution Control 143p., 1967.

The regulations and ordinances have been arranged in sections which include Smoke Emissions and Equivalent Opacity Regulations, Regulations Pertaining to Particulate Emissions from Fuel Burning Plants, Regulations Pertaining to Particulate Emissions from Refuse-Burning Equipment, Regulations Pertaining to Particulate Emissions from Manufacturing Processes, Regulations Pertaining to Sulfur Compound Emission Control, Regulations Pertaining to Hydrocarbon Emission Control, Regulations Pertaining to Fluoride Emission Control, Regulations Pertaining to Motor Vehicle Emission Control, Regulations Pertaining to Odor Emission Control, and Zoning Ordinances. The regulations and ordinances represent the different methods of controlling emissions by law and varying degrees of control. Some definitions were picked selectively to provide very good definitions while others were picked because of their wide use by many states and communities.

01948

J. W. Stephenson

**SPECIFICATIONS AND RESPONSIBILITY FOR INCINERATOR PLANT PERFORMANCE.** Proc. Natl. Incinerator Conf., New York City, 1964. pp. 8-12.

As a result of the growing demand for nuisance-free refuse disposal and the increasing complexity of modern refuse incinerator plants, performance-type plans and specifications for incinerators are no longer acceptable. In addition to basic design, the engineer must now be responsible for demonstrating that the plant operates at the required capacity in a nuisance-free manner and without hazard to health or property. In this paper, the author presents his views of the relative responsibility of state health departments designing engineers, and contractors for proper design and operation of municipal incinerators. He also cites examples of performance-type specification requirements still in use which are not consistent with the best engineering practice.

02393

R. Goder and A. Marshalla.

**INCINERATOR TESTING PROGRAMS 1966.** Proc. Natl. Incinerator Conf. 231-4, 1966. (Presented at the National Incinerator Conference, American Society of Mechanical Engineers, New York City, May 1-4, 1966.)

The progress on incinerator testing programs since the 1964 ASME National Incinerator Conference is reported for several groups. Actions of the Air Pollution Control Association and the Incinerator Institute of America are presented in this paper together with immediate objectives. The Incinerator Institute of America's new test charges, procedures and instrumentation are presented against a background of test results accumulated and studied by the members. Field studies of large numbers of installations are hampered by complex testing

procedures and the industry suffers from a lack of significant data for study. A new procedure to reduce the costs of stack emission tests is outlined. (Author abstract)

03805

**REGULATION 2.** Bay Area Air Pollution District, San Francisco, Calif. May 4, 1960. 51 pp.

A regulation of the Bay Area Air Pollution Control District regulating emissions of certain air contaminants from incineration, salvage, heat transfer, general combustion, and general operations enacted September 1, 1960, is described.

05496

J. W. Bishop L. F. Deming

**ECONOMICS OF SOLID WASTE INCERATION.** Proc. MECAR Symp., Incineration of Solid Wastes, New York City 1967. pp. 51-9.

The economic factors reflected in current and future incineration of refuse are identified. Twenty four hour per day operation for six days per week is a possible specification. Factory fabricated components and automation should be utilized to the maximum. Waste heat should be recovered. Industry may be induced to build and operate incinerator-boilers and utilize the by-product energy. Comparable operations in other process industries should be studied for adaption to incineration. Economic factors affecting future incineration of refuse are different at each location. A complete tabulation of plausible alternate schemes for each facility should be made and economically evaluated prior to selection.

06741

E. S. Monroe, Jr.

**RECENT COMBUSTION DEVELOPMENTS PREVENT AIR POLLUTION - LOW EXCESS AIR FIRING OF HEAVY FUEL OILS AND NEW WASTE INCINERATOR.** 90th Congress 'Air Pollution-1967, Part IV (Air Quality Act)' Senate Committee on Public Works, Washington, D.C., Subcommittee on Air and Water Pollution, May 15-18, 1967. pp. 2597-2601. (Presented at the Joint Technical Conference on Clean Air, Trenton, N.J., Nov. 19, 1964.)

The advantages of stoichiometric combustion or low excess air firing of heavy fuel oils are discussed. A new incinerator for the destruction of waste products is described which utilizes a simplified overfire airjet system. Both of these systems excel in performance and economy and their rapid adoption appears to be to the mutual advantage of industry and the public.

06961

**RULES AND REGULATIONS GOVERNING THE CONTROL OF AIR POLLUTION (AMENDED).** Illinois State Air Pollution Control Board, Springfield. (Mar. 30, 1967). 33 pp.

The first part of the regulations provides rules for existing pollution from refuse or trade waste disposal and emission standards for existing equipment. The second portion deals with rules for control of emissions from new equipment. Examples

of specific items covered are blast furnaces, coke plants, cement kilns, and incinerators.

07202

Tada, H.

**THE REGULATIONS FOR SMOKE ABATEMENT.** Text in Japanese. Kuki Seijo (Clean Air, J. Japan. Air Cleaning Assoc.) (Tokyo), 4(1):1-5, 1966.

The law of smoke abatement was first adopted by the Japanese government in 1960. Prior to that time only local authorities adopted such measures. The regulations are directed against smoke from factories (including the area, facilities, and materials used) and other types of exhaust. The facilities which fall under the regulation are boilers (electric, heat-producing, and those using sulfur-containing fuels), furnaces (calcinating, gas exhausting, sintering, revolving, open hearth), and incinerators. Under the regulation, 'smoke' includes soot, cinders, powdery dust (such as cement dust and iron dust), SO<sub>2</sub> gases, and others. The maximum permissible concentration of smoke is tabulated according to facility, ranging from 0.5 to 2.0 g/cu m at OC and 1 atmos pressure. A smog signal or alert must be issued when the concentration of SO<sub>2</sub> in the air is greater than 0.2 ppm for 3 hr or 0.3 ppm for 2 hr. The system of control and direction is outlined.

07522

Philadelphia Dept. of Public Health, Pa., Div. of Environmental Health

**AIR POLLUTION PROBLEMS FROM REFUSE DISPOSAL OPERATIONS IN PHILADELPHIA AND THE DELAWARE VALLEY.** Preprint, (8 p.), 1965.

The reduction of air pollution emissions from refuse disposal operations is an important aspect of the increased air pollution control efforts in the City of Philadelphia. This report provides current information on the air pollution problems resulting from municipal, industrial and commercial incineration, open burning of refuse and domestic refuse burning. Suggested methods for reducing emissions from these activities are presented.

07879

Essenhigh, R. H. and G. Gelernter

**SYSTEMATIC APPRAISAL OF INCINERATOR RESEARCH REQUIREMENTS.** Preprint, Pennsylvania State Univ., University Park ((34))p., ((1967)) 18 refs. (Presented at the Symposium on Air Pollution Control Through Applied Combustion Science, 16th Annual Meeting, American Inst. of Chemical Engineers, New York City, Nov. 26-30, 1967.)

The possibilities for research operations are so wide that some listing and selection of priorities is necessary to avoid waste of time and money. Such an analysis is presented. The analysis leads to the elimination of research projects at both the engineering development level and the basic sciences level, in favor of research at the intermediate technological level as an initial step. For understanding behavior of even a Test Incinerator, two questions have top priority: (1) What are the conditions for ignition and extinction? and, (2) What are the reaction mechanisms and optimum conditions for most complete burn-up? Division of the incinerator into two Zones, Zone 1 being the fuel bed and Zone 2 being the overfire region of smoke and volatiles burn-up, provides a modifier for the two questions, with priorities becoming: extinction for the fuel bed, and optimization for the flame zone.

08826

**THE AMERICAN PAINT CONVENTION: AIR POLLUTION AND RULE 66 DISCUSSED.** Paint, Oil Colour J. (London), 152(3605):908-912, Nov. 17, 1967. 35 refs.

The discussion of the panel on air pollution at the annual meeting of the Federation of Societies for Paint Technology is reported. The panel consisted of four speakers and a chairman, or moderator, drawn from various parts of industry, and including raw material and equipment manufacturers. The history of the recent legislative proceedings, a review of other local rules and by-laws, problems of reformation and elimination of air-polluting products were discussed by the panel. Rule 66, which was implemented on July 1, 1967, was the final result of prolonged work and followed the drafting of 65 intermediate regulations, some of which threatened the very existence of many industries in Los Angeles. The complicated nature of Rule 66 was made apparent from the numerous printed commentaries in the form of questions and answers. Reverting to methods of control and disposal of excessive air pollution emission as discussed by the panel, three major sources of air-pollution in the manufacture of paint and ancillary products and their use were considered, namely: (1) Resin manufacture; (2) Paint application and drying; and (3) Paint baking. The panel did not concern itself with details of reformulation, otherwise than to indicate the basic problems facing formulations.

08976

Effenberger, Ernst 0897619430

**AIR POLLUTION AND CITY PLANNING.** (Luftverunreinigung und Stadtebau.) Z. Praventivmedizin, Vol. 11, pp. 601-621, Nov.-Dec. 1966. 73 refs. (Translated from German).

The causes of air pollution in the cities are industrial processes (furnace firing), household heating, small businesses, and transport systems. Measures suitable to fight this pollution must attack either at the source (improvement of incinerators, filters, purification of waste gas, etc.) or by permitting a faster distribution and dilution of the pollutants in the air, which can be promoted by measures related to city planning. Some possibilities are: the location of industrial emitters of pollution in that sector of a city with the least wind frequency and screening by parks, increase of the ventilation effect in a city by an appropriate layout of the streets, the promotion of an open building pattern, minimum heights for the smoke stacks of industrial producers of pollution, development main traffic routes without inter-sections, and detours for through traffic, etc. The most important causes of air pollution in the cities are the sources of industrial energy in the form of large-scale incinerators, the heating of households and the exhaust gases of automotive vehicles. Burned are coal and oil or products made of these substances. Incinerators using coal dust and outmoded incinerators are particularly important producers of air pollution.

09500

Department of Health, Education, and Welfare, Washington, D. C., Public Health Service. Executive Order 11282, dated May 26, 1966.

**CONTROL OF AIR POLLUTION ORIGINATING FROM FEDERAL INSTALLATIONS AND STANDARDS BY THE SECRETARY OF HEALTH, EDUCATION, AND WELFARE IMPLEMENTING THE OBJECTIVES PRESCRIBED BY THE ORDER.** 5p. ((1966?))

The Executive Order is reprinted. It presents regulations regarding emission from Federal installations. Included are sec-



tions on: policy, procedures for new Federal facilities and buildings, procedures for existing Federal facilities and buildings, objectives for Federal facilities and buildings, and standards. Performance standards and techniques of measurement prescribed by the Secretary are reproduced here as published in the Federal Register, 31(107) June 3, 1966.

09514

New York State Dept. of Health, Albany, Division of Air Resources

**RECOMMENDATIONS FOR AREA CLASSIFICATIONS. (NEW YORK CITY.)** Preprint, ((18))p., Sept. 7, 1966.

The over-riding factor which must be considered in classifying New York City is the protection of the health of its inhabitants. The density of the population in Manhattan (76,200) in terms of people per square mile is more than twice that of the density of Brooklyn and Bronx (34,600 and 32,900 respectively.) Based on available information, the level of air contamination in New York City is above any standard which may be set. There are three primary sources of pollution in the Metropolitan area. These are: fuel-burning sources, incinerators and motor vehicles. All of New York City, with the possible exception of Staten Island, falls within the definition of Subregion 3; i.e., densely populated, primarily commercial, office buildings, department stores and light industry such as electronics and instruments, apparel and finished products, printing and publishing, and food and kindred products. It is expected that future growth of boroughs in the city. Inspection of the zoning map prepared by the New York City Department of City Planning indicates no proposed radical change in the character of the city. The hub of commercial and industrial activities will continue to be in the lower portion of Manhattan and the western sections of Queens and Brooklyn. The character of the fringes of the city; i.e., northern Bronx, eastern Queens and southern Brooklyn and Staten Island will continue to be primarily single-family dwellings, with scattered apartment houses. While New York City's meteorology is conducive to rapid dilution of dispersion of discharged contaminants, the ability of the atmosphere to do this is often exceeded. It is recommended that: All of New York City be classified C-3 and that the corresponding objectives for this classification as contained in the Ambient Air Quality Objectives-Classifications System be adopted, and a target date of five years be established for meeting these objectives for ambient air quality in the entire city of New York. (Author's summary and conclusions)

09677

Public Health Service, Washington, D. C., National Center for Air Pollution Control

**A COMPILATION OF SELECTED AIR POLLUTION EMISSION CONTROL REGULATIONS AND ORDINANCES. (REVISED EDITION.)** 142p., 1968.

This compilation contains selected sections of many emission control regulations and ordinances. It has been prepared to provide state and local air pollution control agencies, industries, and other interested people with selected examples of the many types of regulations and ordinances in use today. All sections of regulations and ordinances included have been copied directly from the original text of individual state and local laws. The regulations and ordinances have been arranged in such a manner that each section of this report is a compilation of laws pertaining to a specific type of pollutant or pollutant source. These sections include Smoke Emissions and Equivalent Opacity Regulations, Particulate Emissions from Fuel Burning Plants, Particulate Emissions from Refuse-burn-

ing equipment, Particulate Emissions from Manufacturing Processes, Particulate Emissions from Asphalt Batching Plants, Sulfur Compound Emissions, Organic Solvent Emissions, Hydrocarbon Emissions, Fluoride Emissions, Motor Vehicle Emissions, Odor Emissions, and Zoning Ordinances. The regulations and ordinances compiled were selected to represent the different methods of controlling emissions by law and to represent varying degrees of control.

09916

New Jersey Air Pollution Control Commission, Planning Committee

**WHERE DOES NEW JERSEY GO FROM HERE IN AIR POLLUTION CONTROL?** Preprint, 44 p., July 18, 1966.

Past and present accomplishments in air pollution control from the year 1954 to the present are discussed including the following subjects: population growth; motor vehicle increases and pollutants; consumption of fuel and electric power; and industrial growths. Standards and enforcement of codes on open burning, landfill, incinerators, particulates, sulfur compounds and motor vehicles are summarized. Twenty-six recommendations were made to the Commission for improvement in control programs, standards, codes, enforcement and other administrative procedures for controlling air pollution.

10454

Vaughn, Richard D.

**ASSISTANCE AVAILABLE UNDER THE SOLID WASTE DISPOSAL ACT.** Compost Sci., 9(1):15-17, 1968.

Title II of Public Law 89-272, The Solid Waste Disposal Act, is a Federal commitment to support and assist in a coordinated effort to solve solid waste problems. Some of the research and demonstration projects underway are reviewed briefly. Approaches such as landfill steam generation and water desalinization incinerators, and long distance hauling of waste are mentioned. Specifics of the Act are considered, such as research grants, training assistance, and support of various State survey and planning projects.

10491

Sableski, J. J., J. C. Knudson, W. A. Cote, and J. F. Kowalczyk

**DEVELOPMENT OF INCINERATION GUIDELINES FOR FACILITIES.** Preprint, Public Health Service, Durham, N. C., National Center for Air Pollution Control, 35p., 1968. 7 refs. (Presented at the 61st Annual Meeting of the Air Pollution Control Association, St. Paul, Minn., June 23-27, 1968, Paper 68-98.)

The efforts of the National Center for Air Pollution Control to develop guidelines for incinerators at Federal facilities are discussed. The guidelines were developed to aid purchasing agents and other technical people in Government to select, operate, and maintain general refuse and pathological incinerators so that they meet the standards for particulate emission set forth in the Code of Federal Regulations. The first guide issued, the 'Interim Guide to Good Practice for Selecting Incinerators for Federal Facilities,' is discussed. The Guide recommends the Los Angeles County Air Pollution Control District design of incinerators and gas washers. Other incinerator and washer designs may be used if standard testing procedures outlined in the Interim Guide clearly show that they can maintain emissions within the limits set by the Code. The test program conducted to evaluate existing incinerator and washer designs is also discussed. Preliminary results from the PHS testing program are presented. Indications are that com-



monly employed, uncontrolled incinerators will not meet the Federal Standards relating to grain loadings. However, where scrubbers having pressure drops of at least 0.5 inches of water and water flows of 4 gallons per 1,000 scf are used, incinerators may meet 2 of the 3 particulate standards. Revision of the third standard, relating to the emission of particles over 60 microns in size, is under consideration. (Authors' abstract)

10567

**AIR POLLUTION CONTROL.** Philadelphia Med., 64(14):658, July 20, 1968.

The Air Pollution Board of Philadelphia has adopted revised incinerator regulations which will prohibit the issuance of permits for the construction of new incinerators used in the disposal of ordinary apartment-commercial-industrial refuse after January 1, 1969. Within one year of that date, all incinerators are to be equipped with devices to meet stringent emission standards; all current incinerator owners will be required to certify by February 1, 1969, that their units will be shut down, upgraded, or replaced. The new regulations call for installation of equipment which will reduce particulates in flue gas to 0.2 or 0.6 lb./100 lb. gas, depending on gas charging rate; for smoke emission density not exceeding Ringelmann No. 1 or its equivalent for more than 30 sec. in any one hour or a total of 3 min. in any day; and for control of odors from incinerators such that odors shall not be detectable in any area for human use or occupancy. These regulations must be approved by the Philadelphia Board of Health, and by the City's Law and Records Departments, after which a final adoptive date will be established.

11095

Venezia, Ronald A.

**CONTROL OF AIR POLLUTION FROM FEDERAL FACILITIES.** Preprint, Public Health Service, Washington, D. C., National Center for Air Pollution Control, 15p., 1968. (Presented at the 61st Annual Meeting of the Air Pollution Control Association, St. Paul, Minn., June 23-28, 1968, Paper 68-176.)

It is the Federal Government's intent to be exemplary in controlling air pollutant emissions from its facilities. The basic documents used are the Clean Air Act, Executive Order 11282, and regulations pursuant to it, and BOB Circular A-78. Most regulations cover all Federal Facilities located in the United States and certain possessions, making distinction in some methods of refuse disposal between urban and rural areas. Other regulations are specific for certain metropolitan areas with extensive air pollution problems. Each agency has surveyed its facilities to define the air pollution problem and solutions have been proposed to be implemented in a Government-wide 5-year program. This program is subject to updating and review each year. (Author's abstract)

12511

Stumph, Terry L. and Robert L. Duprey

**TRENDS IN AIR POLLUTION CONTROL REGULATIONS.** Preprint, Air Pollution Control Association, New York City, 40p., 1969. 19 refs. (Presented at the Air Pollution Control Association, Annual Meeting, 62nd, New York, June 22-26, 1969, Paper 69-175.)

Recent trends in air pollution control regulations adopted by state and local agencies were analyzed. Emphasis was on the concepts of control regulations rather than on specific emission limits. Trends in control regulations are towards preventing air pollution through required application of known control techniques. Outmoded concentration emission standards are

rapidly being replaced by those that limit total mass-emission rates. Allowable emission rates usually vary according to the size of the source. Control of all visible emissions is being accepted as necessary to any control program. Particulate matter from fuel-burning equipment is being controlled to a high degree; emission standards for sulfur oxides from fuel combustion are anticipated in the near future. Incinerator emissions standards are relatively undeveloped, due to lack of knowledge about the performance of high-efficiency dust collectors on these sources. Control of many types of process industries presents a challenge in the design of equitable emission standards. The familiar process-weight-rate regulation is rapidly becoming the standard for limiting particulate matter from this source category. The potential emissions-rate concept shows promise for certain source types and pollutants. Odor regulations have mainly involved ambient air measurements using the human sense of smell. (Author abstract modified)

12989

Simons, Wilhelm

**EMISSION MEASUREMENTS AT SMALL INCINERATORS.** (Emissionsmessungen an kleinen Mullverbrennungsanlagen). Text in German. Tech. Veberwach. (Duesseldorf), 7(12):413-415, Dec. 1966. 3 refs.

The new law of September 8, 1964 to prevent air pollution requires that plants with a capacity of less than 20 tons per day emit not more than 200 mg dust referred to 1 cu m moist waste gas and a CO<sub>2</sub> content of 7%. The smoke plume may not exceed the No. 2 gray shade on Ringelmann's scale. Moreover, the law stipulates that all incinerators be equipped with auxiliary burners, since all solid components must be burned completely. Measurements are required to prove compliance with the law. Up to now a total of 220 measurements had been taken at 49 small incinerators of 10 various manufacturers. All incinerators had an afterburner and usually two auxiliary burners in the main combustion chamber. Domestic wastes, paper, and hospital wastes were ashed. Of the 49 incinerators, 38 were equipped with dust separators. Results of the measurements show that 75% of the incinerators emitted dust concentrations below the tolerance limit. The good results for those incinerators without dust separators can be explained by the fact that favorable combustion conditions were maintained. Furthermore, these furnaces burned only domestic wastes and paper. A study of the relationship between the various types of wastes fired in the furnaces and dust emission showed that they have but little effect on keeping the dust emissions below the tolerance limit. The percentage of furnaces which do not exceed the tolerance limit increases from 72 to 86% with increasing volume of the combustion chamber. Measurements of the temperatures during the combustion process showed that all were above 800 C at the peak of the combustion, after which they fell to 700 C. No disagreeable odors were noticed. The CO<sub>2</sub> concentrations measured ranged from 1.7 to 7.0%. Thus, it can be safely concluded that these small incinerators pose no danger to their surroundings.

16343

**CONTROL OF AIR POLLUTION.** Intern. Digest Health Legislation, 20(3):499-512, 1969. (Original text in Public General Acts and Measures of 1968, Chapt. 62, p. 1523-1538, 1969.)

The British anti-air pollution act is presented in its entirety in addition to supplements, schedules, and means of administration. Various terms are defined. Limits on the rates of emission are prescribed. The uses of furnaces are standardized,

and the over-all policy of the act is provided. The emissions covered include dark smoke, grit, dust, and fumes.

18108

Luce, Charles F.

**NEW YORK CITY TAKES INVENTORY: HOW CLEAN IS THE AIR.** *Air Eng.*, 11(2):14-16, February 1969.

New York City Local Law 14, although under attack in the courts, is in effect today. The efforts of the New York City administration to comply with this law is discussed. Con Edison, as one of the contributors to pollution, has met or will meet within the established deadlines, every single requirement imposed on the company by Local Law 14. Their attack on the problem is discussed. The problems that exist in the city are reviewed.

19059

Bistowish, Joseph M.

**NASHVILLE'S AIR POLLUTION PROBLEM: PAST, PRESENT AND FUTURE.** Vanderbilt Univ., Nashville, Tenn., School of Engineering, Tennessee Stream Pollution Control Board, Tennessee Dept. of Public Health, Proc. Conf. Environ. Water Resources Eng., 8th Ann., Nashville, Tenn., 1969, p. 171-177. (June 5-6).

The provisions and implementation of an air pollution control ordinance prepared by the Nashville Health Department are discussed. The ordinance regulates visible emissions from all fuel or refuse burning equipment. It is unlawful to burn any solid or liquid fuel containing more than 2% sulfur by weight. New incinerators must be multiple chamber incinerators having capacities of 100 lbs/hr with auxiliary heat sources to prevent air pollution. No incinerator may emit fly ash or other particulates in excess of 0.2 grain/cu ft. Automobiles and trucks may not emit visible air contaminants in excess of Ringelmann No. 1. The ordinance also regulates odors, dusts, and emissions from laundries, dry cleaning plants, and similar operations. The air pollution control division is divided into three sections: engineering, enforcement, and laboratory. The progress of implementation of the ordinance is also discussed.

20133

Ireland, F. E. and D. H. A. Price

**INCINERATION: STATUTORY REQUIREMENTS AND ENVIRONMENTAL ASPECTS.** *J. Inst. Fuel* (London), vol. 43:115-119, April 1970.

Statutes concerned with airborne effluents and liquid wastes from incinerators are stated, and some brief notes are given on the more important requirements and their fields of application. Emissions of smoke from incinerators must not be as dark as or darker than shade 2 on the Ringelmann Chart; any practicable means must be used to minimize the emission of grit and dust (the Clean Air Acts of 1956 and 1968). The Works Regulation Act (1906) is administered by inspectors of the central authority to control emissions from works for the destruction by burning of wastes produced in the course of organic chemical reactions and works in which metal is recovered from scrap cable by burning the insulation. The Radioactive Substances Act (1960) deals with the disposal of radioactive waste. Chimney height determination is an extremely important aspect of incinerator design, while the three most important facets to minimize air pollutants from municipal incinerators are efficient combustion, arrestment of particulate matter, and height of dispersion. Waste water may be discarded to the sewer of the Local Authority, to an inland water course or estuary, to the sea, or soaked away on land.

The various controlling bodies are empowered to stipulate conditions regarding the volume, composition, and the characteristics of the discharge. Strongly acidic or alkaline waters may be troublesome, and upper and lower limits for pH are usually imposed. A maximum permissible temperature is also often stipulated. A Local Authority controls discharge to sewers, and the River Authority controls discharges to inland and tidal waters.

20861

Henderson, J. S.

**PLANNING FOR AIR POLLUTION CONTROL. PART 1: LAWS AND THEIR IMPACT.** *Plant Eng.*, 24(12):94-97, June 11, 1970.

The Clean Air Act of 1967 designates 91 air quality control regions and makes each state responsible for adopting regional air quality standards and for developing an abatement procedure plan. The central cities of the air quality control regions are specified in this article, and the need of control agencies to include emission standards in their implementation plan is discussed. Typical standards for particulate emissions from coal-fired boilers, manufacturing processes, and incineration are summarized, as are representative ambient air standards for particulates and sulfur dioxide. Some state and local laws require all emission sources to meet both pollution emission and plume visibility standards. Plant engineers may also face compliance with other types of requirements and restrictions. These may include industrial source registration, including quantities and location of pollutant discharges; registration of plant expansions or process changes; plant access and inspection by control authorities; provision of stack sampling ports and platforms, and continuous monitoring of stack discharges.

22466

Ordinanz, Wilhelm

**A NEW AIR POLLUTION LAW.** Staub (English translation from German of: Staub, Reinhaltung Luft), 29(9):8-10, Sept. 1969. 7 refs.

The Air Pollution Law of Michigan (1967) stipulates licensing for the erection, mounting, or alteration of combustion equipment or other working processes liable to emit pollutants. An application must be submitted with the following information: quantity and temperature of the waste gas or air; the composition of waste gases with or without scrubbing; prospective content of solids in the waste gases; point of emission; height and location relative to adjacent buildings; other factors liable to facilitate the diffusion or emission in the surroundings; and information on special effects of the pollutants. The gray value of smoke plumes from furnaces must be brighter than No. 2 on the Ringelmann scale, but gray value No. 2 must not prevail for more than 3 minutes every half-hour and gray value No. 3 for no longer than 3 minutes in an hour, though not more than three times in 24 hours. Permissible limits of dust emission are presented tabularly for combustion plants, garbage incinerators, steel production, cupola furnaces for cast iron, lime kilns, asphalt preparation, cement production, and pelletizing of iron ore. Several prohibitions are also listed.

23126

Dept. of Interior (West Germany), Advisory Council for Environmental Planning

**WATER BALANCE, AIR POLLUTION CONTROL AND WASTE DISPOSAL.** (Wasserwirtschaft, Luftreinhaltung und Abfallbeseitigung). Text in German. *Wasser Luft Betrieb*, 14(7):290-292, July 1970.



Recommendations of the Advisory Council for Environmental Planning concerning air and water pollution and waste disposal analyze the consequences of pollution on the environment, stipulate maximum permissible levels of the various pollutants, and estimate the quantities of industrial waste, of household waste, and of clearing sludge which have to be disposed of in communities of various sizes. The installation of an incinerator pays only if it services at least 100,000 inhabitants otherwise its capacity remains unused. Smaller communities therefore must dump their waste in regional dumps but the constant operation of a bulldozer which is necessary is economical only for dumps servicing at least 15,000 inhabitants. To prevent contamination of ground water through waste deposits, an impermeable layer at least 1 m thick must separate the two zones. Of decisive importance is the correct choice of the site for dumps, orderly and controlled dumping, the proper utilization of qualitatively harmless clearing sludge compost, and suitable dumping site selection for especially objectionable materials like used oil, chemical, and radioactive waste. To the degree that waste can be composted this should be done together with the clearing sludge because such compost is better suited for use in agriculture. Superregional solutions must be found for the disposal of abandoned cars. Regional planning must provide for the selection of dumping grounds.

23765

Sabis, William R., David H. Scott, and David B. Smith  
**COMPREHENSIVE WATER SUPPLY, SEWERAGE, SOLID WASTE AND AIR POLLUTION CONTROL PLANS.** David B. Smith Engineers, Inc., Gainesville, Fla. Proj. 6914, HUD Proj. FLA. P-104, 139p., Feb. 1970. 11 refs. CFSTI: PB-191553

A long range comprehensive plan for Palm Beach County, Florida regarding air pollution control, water supply, sewerage, and solid wastes disposal is presented. A geographical description of the area, including land use and trends, population projections, and transportation networks is provided. A report of air quality measurements in the area is included. Sources in the area include incinerators, automobile exhausts, certain industrial discharges, dumps, and agricultural operations. An air pollution control plan, under the auspices of the Air Quality Act, is recommended. It includes the establishment of an air quality region and suitable enforcement and regulatory measures.

25480

Resources Research, Inc., Washington, D. C.  
**PROPOSED IMPLEMENTATION PLAN FOR THE CONTROL OF PARTICULATES AND SULFUR OXIDES FOR THE COMMONWEALTH OF KENTUCKY PORTION OF THE METROPOLITAN CINCINNATI INTERSTATE AIR QUALITY CONTROL REGION.** NAPCA Contract CPA 70-29, 239p., Sept. 1970. NTIS: PB 195760

The Metropolitan Cincinnati Interstate Air Quality Control Re-

gion, (MCIAQCR), designated on May 2, 1969, comprises approximately 3000 square miles of land area located in the extreme southwestern portion of Ohio and the adjacent states of Kentucky and Indiana. There is a total of nine counties in the MCIAQCR, which is primarily an industrial area. The proposed regional particulate control strategy consists of emission standards covering three general categories of emission sources: industrial process, fuel combustion, and solid waste disposal. The proposed regional sulfur oxides control strategy consists of those emission standards on which regulations already in effect in Cincinnati are based. Emission categories considered by these standards are industrial process and fuel combustion. Implementation of control regulations divides into two separate tasks. First, the new regulations must be officially adopted by the responsible state agency. Second, field enforcement and control of pollution sources affected by the regulations must be carried out. The primary portion of the Kentucky enforcement program will be a permit and source surveillance system. Deficiencies in Kentucky's existing air pollution control program are pointed out and remedies suggested to enable implementation of the new regulations, which are cited. Also described are the projected regional air quality monitoring network and procedures to be used to control sources during emergency episodes.

25688

Resources Research, Inc., Washington, D. C.  
**PROPOSED IMPLEMENTATION PLAN FOR THE CONTROL OF PARTICULATES AND SULFUR OXIDES FOR THE STATE OF OHIO PORTION OF THE METROPOLITAN CINCINNATI INTERSTATE AIR QUALITY CONTROL REGION.** NAPCA Contract CPA 70-29, 238p., Sept. 1970. NTIS: PB 195758

The Metropolitan Cincinnati Interstate Air Quality Control Region (MCIAQCR), designated in May 1969, comprises approximately 3000 square miles of land area located in the extreme southwestern portion of Ohio and the adjacent states of Indiana and Kentucky. The proposed regional control strategy for particulates consists of emission standards covering three general categories of emissions: industrial process, fuel combustion, and solid waste disposal. The proposed control strategy for sulfur oxides consists of those emission standards already in effect in Cincinnati: the emission categories considered by these standards are industrial process and fuel combustion. When adopted and enforced, these strategies should lead to acceptable levels of both suspended particulate and sulfur dioxide as defined by regional Air Quality Standards. Legally enforceable control regulations based on the emission standards are presented. In Ohio, the regulations will be implemented primarily through a permit and source surveillance system. Legal and administrative deficiencies hindering enforcement of the control plan in Ohio are pointed out, and remedial measures suggested. Also reviewed are the projected regional air quality monitoring network and procedures to be used to control sources during emergency episodes.



## M. SOCIAL ASPECTS

06085

M. Sterling

**ATTITUDES ON THE DESIGN OF FLUE-FED INCINERATORS.** J. Air Pollution Control Assoc. 10 (2), 110-3, 174 (Apr. 1960). (Presented at the 52nd Annual Meeting, Air Pollution Control Association, Los Angeles, Calif., June 22-26, 1959.)

An attempt has been made to ascertain present attitudes of air pollution control officials and equipment manufacturers on the preferred design of new flue-fed incinerators. The basic flue-fed incinerator has undergone little change until a few years ago when the effects of air pollution legislation required that existing units be modified. Fifty-six air pollution control agencies and 14 incinerator manufacturers were contacted, and answers to the questionnaire suitable for data abstraction were obtained from 33 of them. Fifty-five percent of the respondents felt that there is a value in the use of flue-fed incinerators. The balance felt that if incineration were the desired disposal technique, it should be accomplished in suitably designed commercial incinerators. Some distinctive features to be used as a basis for the design of the unit determined by the consensus from the poll, are discussed. (Author's conclusions, modified)

14805

Johnson, K. L.

**CITIZEN COMPLAINTS OF AIR POLLUTION IN NORTHEASTERN ILLINOIS.** Preprint. Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, 17p., 1967. (Presented at the 60th Annual Meeting of the Air Pollution Control Association, Cleveland, Ohio, June 11-16, 1967, Paper APCA 67-176.)

An examination was made of citizen complaints of air pollution registered with air pollution control agencies representing the City of Chicago, outlying Cook County, and the State of Illinois. The complaint files of the City of Chicago contained the addresses of some 9500 air pollution sources specified by complainants in complaints covering the time period from approximately 1954 to 1964. A statistical sample of these sources showed more than 70% to be of a non-industrial nature, with domestic fuel burning or incineration by neighbors most often specified. There were 1119 industrial process sources named in the Chicago files, 588 nonmanufacturing and 531 manufacturing. Fabricated metal industries, primary metal industries, chemical manufacturers, and food processing plants were cited more often than other industrial categories. Complaint sources named in complaints filed by citizens with the state of Illinois, and with Cook County, differed with those of Chicago in that industrial sources were specified more often than nonindustrial ones. The reason for this is believed to lie in the reduced residential densities and the relatively great use of pollution free fuels in the metropolitan area outside of the City of Chicago. (Author abstract modified)

15002

Myrick, Richard and Barbara Spencer Marx

**THE CONTROL OF INCINERATOR-CAUSED AIR POLLUTION IN NEW YORK CITY: 1946-1965.** George Washington Univ., Washington, D. C., Paper 202, 63p., March 1968. 157 refs. CFSTI, DDC: PB 182 874

New York City's efforts during the past twenty years to assess and control undesirable effects from air pollution caused by incinerators, is documented in case history form. The changing attitudes and approaches, and interplay between different governmental, industrial, and civic entities are shown. Their opposing interests and viewpoints made the struggle to achieve, a solution ineffectual. It is concluded that efforts to control pollution were consistently piecemeal and narrowly conceived. The task was assigned to one governmental department, yet the problem concerned a number of departments. Consequently, the responsibility and authority, together with the necessary coordinating machinery, to provide an across-the-board solution to air pollution did not exist. The city stressed social, political, and behavioral solutions instead of technological ones. It was doubtful that the issue of pollution from apartment house incinerators ever became part of the public awareness. The problem of air pollution abatement started as a relatively insignificant problem. It temporarily became one of high priority, and then subsided. As soon as the Department of Air Pollution Control was formed public concern declined. Incidents of attempted control were viewed as a struggle between two factions, each composed of a number of different groups whose power to influence events varied somewhat over time. One faction in the struggle for control comprised those organizations who were most conspicuously and effectively fighting pollution; the citizens groups, dedicated or threatened officeholders, and the press. The strength of this faction was that it has the ability to arouse public opinion and press for action. Its weakness was that it has no administrative power. The other faction consists of apartment building owners and operators, and city officials who were responsible for the operation of municipal facilities. Their strength was that nearly everyone in the city was dependent on them for services. Their weakness was that they lacked both technological and behavioral solutions to the air pollution problem.

24009

Capital District Regional Planning Commission, Albany, N. Y. **AIR POLLUTION.** In: Physical Resources. Dec. 1969, p. 3.10-3.20. 4 refs. CFSTI: PB-190176

While the problems presented by precipitation, temperature, and wind conditions must be considered and planned for in the construction of various facilities and the location of land uses, there is one major problem associated with climate which is man made and can therefore be altered. Causes, ingredients, problem areas, and controls of air pollution are mentioned. Surface based and subsidence temperature inversions are discussed, as well as emissions from industrial processes, fuel combustion, and incineration. New York State ambient air

## M. SOCIAL ASPECTS

77

quality standards and the land use association for the five general levels of air contamination are presented. Guidelines are suggested for use in anticipation of problems associated with climatic conditions in future regional planning. Issues and implications, trends, and economic factors are cited. The

available organizations for the implementation of control plans at the state, regional, and municipal levels are described and their working tools, from state regulations and legislation to municipal ordinances, are considered.

## N. GENERAL

00164

**STATISTICS ON PARTICULATE CONTAMINANTS - SAN DIEGO COUNTY AIR POLLUTION CONTROL DISTRICT (FIRST QUARTER 1966).** San Diego Dept. of Public Health, Calif. Mar. 1966. 7 pp.

First Quarter 1966 Statistics on Particulate Contaminants San Diego County Air Pollution Control District are presented. Data are included on weight concentrations from high volume filter samples, soiling indexes, and hourly averages of gaseous contaminants.

01531

G.H. Ball

**AIR POLLUTION CONTROL IN EDMUNTON.** Can. J. Public Health (TORONTO), 57(2) 83-84, FEB. 1966.

The recent industrial growth of Edmonton has resulted in air pollution control problems. Suggestions given for improvement include the ban of domestic incineration, use of a sanitary landfill disposal system, and the location of industrial plants that produce offensive odors in one central industrial area. Despite the problems, the author concludes that the anti-pollutant laws of Alberta Province are adequate.

22326

Rotterdam Soil, Water and Air Committee (Netherlands)

**SOIL, WATER AND AIR COMMITTEE ROTTERDAM. REPORT FOR THE YEAR 1966.** (Commissie bodem, water en lucht Rotterdam. Verslag over het jaar 1966). 59p., 1967. Translated from Dutch. Franklin Inst. Research Labs., Philadelphia, Pa., Science Info. Services, 96p., Oct. 6, 1969.

The annual report from Rotterdam's Soil, Water and Air Committee is presented. The activities of municipal and private companies in terms of pollution control are discussed. The electric company addition will burn only natural gas; the new waste disposal unit is designed to be essentially pollution-free; abandoned cars are being removed from the roads. Specific problems in local air, water, and soil areas are discussed. The results of a study relating air pollution to sickness and death are presented. Atmospheric conditions and contaminant measurements made during 1966 are tabulated. Included are rainfall, smoke, wind characteristics, hydrocarbons, metals, carbon monoxide, nitrogen dioxide, sulfur dioxide, and pH. Proposals for the formulation of rules for maximum emission concentrations are being studied.



# AUTHOR INDEX

## A

ALBINUS, G A-11427, \*B-02976  
 ALKIRE H L A-23313, \*A-23314  
 ALLEN, D R A-00027  
 AMALRAJ R V B-23856  
 ANDERSEN L H B-18252  
 ANDREONI, G A-08577  
 ANDRITZKY, M A-11411, \*A-11637  
 ANGENEND, F J A-11638  
 ARIEY A F B-16730  
 ASUKATA R B-14364

## B

BACHL H A-11968  
 BACHL, H A-10678, \*A-11640  
 BALDEN, A R A-07659  
 BALL, G H N-01531  
 BARBEITO M S A-20517  
 BASDEN, K S A-10418  
 BAUM, F A-08373, \*C-08257  
 BECK H A-13112  
 BELL G B D-22812  
 BELOUSOV, S P B-08178  
 BENDER, R J A-06937  
 BENFORADO, D M B-07921  
 BENLINE, A J K-05197  
 BEORSE, B A-05969  
 BERGSTEN, A B-04843  
 BILLARD F B-24465  
 BISHOP, J W L-05496  
 BISTOWISH J M L-19059  
 BISWAS B K B-22821  
 BLOCK H A-11963  
 BOHNE H A-24421  
 BOHNE, H H-09275  
 BOUBEL, R W A-06370  
 BOYER, R H JR J-02392  
 BRANCATO, B A-07206  
 BRANDT H B-23482  
 BRAUN W B-20773  
 BRION J B-21435, B-24465  
 BUMP, R L B-02387  
 BURCKLE, J O A-09026  
 BUSH, A F A-05969

## C

CAFIERO, A S B-02399  
 CALACETO R R B-24089  
 CAMPBELL, H J JR B-12664  
 CANTER L W C-24412  
 CAROTTI A A A-14923  
 CATES H J JR B-20728  
 CEDERHOLM, C B-02027  
 CELAYAN G G B-20294  
 CERNIGLIA, V J B-02388  
 CHALLIS, J A B-02389  
 CHANSKY S H A-22860, \*A-22862,  
 \*B-22808  
 CHASS, R L A-09785  
 CHIPMAN, R D A-05969  
 CLARK W T B-15201  
 CLARKE, J F D-00149

CLEARY, G J A-10424  
 COHAN, L J A-09663  
 CONNELL, J M A-09158  
 COONS, J D B-00288  
 COPE, W C D-03454  
 CORN, M A-00027  
 COTE, W A L-10491  
 COUSIN M B-21435, B-24465  
 CRABAUGH H R A-24767  
 CRAWFORD G C-14368  
 CROSS F L JR A-19052, \*K-14366  
 CROUSE, W R A-03154  
 CUNNAN, J F A-00673

## D

DANIELSON, J A B-09784  
 DARNAY A J JR A-18009  
 DAVIES T E B-23819  
 DAVIS, U C B-07973  
 DEALY, J O B-06084  
 DELARUE R B-24465  
 DEMING, L F A-09158, L-05496  
 DENNIS, R B-06315  
 DICKINSON, J A-09785  
 DIMITRIOU A N A-22860, A-22862,  
 B-22808  
 DORSEY, J A A-09026  
 DUHME A A-11963  
 DUN, A S B-08178  
 DUPREY R L L-12511  
 DUPREY, R L A-09686  
 DVIRKA M B-13133  
 DVIRKA, M A-10038

## E

EASTLUND B J B-19941  
 EBERHARDT H A-11940, \*B-14369  
 EBERHARDT, H B-02390  
 EDWARDS, L V C-02391  
 EFFENBERGER, E L-08976  
 ELLSWORTH R D B-19550  
 ENGDAHL R B B-14967, B-19550  
 ENGEL, W A-11412  
 ERMER H A-11962  
 ERNST AND ERNST J-11114  
 ESSENHIGH R H A-20906, B-22821,  
 F-14370  
 ESSENHIGH, R H A-11475, F-09284,  
 \*L-07879

## F

FAATZ A C A-26204  
 FAESSLER K I-14737  
 FAORO, R B D-00149  
 FELDSTEIN M C-25696  
 FELDSTEIN, M C-05834, C-08675  
 FERBER M A-11969, \*A-11971  
 FERNANDES J H B-14365, \*B-19896  
 FERNANDES, J H A-09663  
 FEUSS, J V A-10675  
 FICHTNER, W A-03868  
 FIELD E L A-22860, A-22862, B-22808

FIFE, J A B-02738, \*B-06588, \*B-10009,  
 \*J-02392  
 FISCHER, F A-11647  
 FLOOD, L P B-00183  
 FLOWER, F B A-10675  
 FLOWERS G H JR A-20737  
 FLYNN, N E A-03154  
 FRANKEL, J I A-03155  
 FRANZKE H H A-21882  
 FRIEDLAND, A L B-12664  
 FUDURICH, A P C-06095  
 FUJII S B-15396  
 FULLER L J A-11803

## G

GARRETSON B B B-16730  
 GELERNTER G F-14370  
 GELERNTER, G L-07879  
 GEORGE R E A-11803  
 GERHARDT R A-11962  
 GILLULY R H G-23167  
 GODER R K-12118  
 GODER, R A-05877, \*B-01942, \*L-02393  
 GOLUEKE, C G B-02741  
 GOUGH W C B-19941  
 GREELEY S A A-19547  
 GREMILLION G G A-20517  
 GRISWOLD, S S B-00107  
 GRUBER C W C-19580  
 GRUBER, C W C-01612, C-07077  
 GRUETSKY, W A-11649

## H

HAEDIKE, E W B-02394  
 HALITSKY J B-22757  
 HALITSKY, J A-07561  
 HAMMING, W J A-09785  
 HANGEBRAUCK R P B-15544  
 HANGEBRAUCK, R P A-01788, \*A-05005  
 HANGEBRAUCK, T P B-02232  
 HANSEN E G A-17552  
 HANSTEDT, W A-11651  
 HASHIMOTO K B-17403  
 HAZZARD, N D B-07921  
 HEER H B-23482  
 HEIN G M B-14967  
 HENDERSON J S L-20861  
 HERRICK, R A A-06086  
 HESCHELES, C A A-03870, \*A-05497  
 HIRAYAMA N A-20646  
 HISHIDA K A-20646, \*B-16137, \*K-17201  
 HONDA A I-19325  
 HORSLEY, R R A-00027, A-06086  
 HOTTI G A-21492  
 HOURY E A-20153  
 HOVEY, H H A-00673  
 HOWARD, W C B-07769  
 HUME, N B A-06852

## I

INCINERATOR INST OF AMERI A-07804  
 IRELAND F E L-20133

## MUNICIPAL INCINERATORS

ISHII I A-14168  
ISHII K A-25056  
ISHITSU F B-21058  
ITO A B-23262  
ITO H I-19325  
IVERSEN, N S A-02009

## J

JACKSON M R C-15533  
JACOBI, J W A-00712  
JACOBS M B B-22757  
JACOBS, M B A-07561, \*G-01941  
JENS, W B-00968  
JOACHIM H A-11961  
JOFFRE R B-22156  
JOHNSON K L M-14805  
JOHNSON, H C B-00288

## K

KACHULLE, C A-11655  
KAIN H W A-20153  
KAISER E R A-14367, \*A-16869, \*A-21952,  
\*B-11792, \*B-22757, \*B-22822  
KAISER, E R A-05492, \*A-07561,  
\*A-09671, \*B-01437, \*B-01935,  
\*B-01947, \*D-02395  
KALLENBACH, K A-11449  
KAMITSU K A-17462, A-22130  
KAMMERER, H F A-11413  
KAMPSCHULTE, J A-11431  
KANE, J M B-08837  
KANTER, C V C-06095  
KAUPERT W A-18173  
KAWASHIMA T A-17462, A-22130,  
B-14364  
KEAGY, D M B-00288  
KERN, A A-11430  
KETTNER H A-25549  
KHAN A A B-23856  
KINNEY L J A-23815  
KIROV, N Y A-10433, \*B-08632  
KITREDGE G D B-15544  
KLEIN N C-20808  
KMOCH, H B-11652  
KNOLL, H A-11440  
KNUDSON, J C L-10491  
KOIZUMI M A-25056  
KOLP, P W A-00027  
KONDO K I-19325  
KONNO S A-20646  
KOWALCZYK, J F L-10491  
KREICHELT, T E A-02414  
KUHLMANN A A-14442  
KURKER, C B-10694  
KUROSAWA K B-16536  
KURTZ, P A-05969  
KUSUMOTO M A-17243  
KUWATA, M A-11475

## L

LAMANTIA C R A-22860, A-22862,  
B-22808  
LANGMANN R A-25549  
LARSON G P B-14522  
LARUE P G B-17275, \*B-23836  
LAUSMANN J S B-25570  
LEIB H I-14737  
LENEHAN J W B-19987  
LEUDTKE, K D A-05160  
LEVIN H C-17352  
LEVY Y C-20808  
LIEBERMAN A C-15533  
LUCE C F L-18108

LUDWIG, J H A-00943, A-07963  
LUGE K E B-20773  
LUNCHE, R G C-06095  
LYNCH, F J B-01946

## M

MACHIYAMA T A-25056  
MACKNIGHT, R J B-06084, \*B-09823  
MAIKRANZ F A-11968  
MAIKRANZ, F A-11640  
MANDELBAUM, H B-07426  
MARSHALLA A C-14368  
MARSHALLA, A L-02393  
MARX B S M-15002  
MATSUMOTO K B-14364  
MAURER, K G A-03868  
MAYER W B-14369  
MAYER, M A-00972  
MCCABE L C B-22757  
MCCABE, L C A-07561  
MCCAFFERY J B B-22822  
MCCLURE E R B-25511  
MCCUTCHEN G D A-24582  
MCGAUHEY, P H B-02741  
MEEKER, J E A-01788, A-05005  
MEISSNER, H G B-01936  
MEYER, G A-11657  
MICHAELS A A-19547  
MICHAELS, A B-04843  
MILLS, J L A-05160  
MINER S A-17610  
MIRUS E C B-05569  
MIZUSHIMA, J A-05969  
MOEGLING, E A-11438  
MONROE, E S B-02396  
MONROE, E S JR L-06741  
MOORE, H C A-05493  
MOWBRAY, K S B-02394  
MUELLER, H J A-11428  
MUKAI, M F-01798  
MULLER, H A-03868  
MURAKAMI M A-17462, \*A-22130  
MYRICK R M-15002

## N

NAGATA K A-25056  
NAITO J B-15396  
NETZLEY, A B B-09824  
NIESSEN W R A-22642, \*A-25220,  
B-14612  
NIKBERG, I I B-08178  
NOLAN M C-14368  
NOWAK, F I-12055  
NUBER K A-11939

## O

OBERING E A B-13697  
OCHS, H J B-11658  
OHIRA T A-20646  
OHYANAGI T B-23262  
OKUDA M A-25056  
ORDINANZ W L-22466  
ORNING, A A-05465  
OSTERLI V P B-25977

## P

PALM R A-11972  
PALM, R A-11447  
PASCUAL, S J B-01940  
PAULETTA, C E B-07921  
PEARL D R B-13363

PELLETIER E A-20759  
PERRY, L B A-05160  
PESKIN, L C A-08090  
PETERS, W A-11448  
PETERSON F C-23437  
PIERATTI, A B-01940  
PORTEOUS, A A-09676  
POTTINGER J F B-16751  
PRICE D H A L-20133  
PRIDDY M H B-20078  
PRITCHARD, W L C-01612, \*C-07077  
PUBLIC HEALTH SERVICE L-09677  
PURDOM, P W B-04843

## R

RAMIRES W C B-20730  
RASCH R A-11934, \*I-16420  
RATHGEBER F B-14736, \*B-26063  
REED, R D B-04838  
REED, R J B-05852  
REH L F-13618  
REHM, F R B-00968, \*B-06096, \*C-04117  
REICHARDT, I C-08257  
RILEY, B T A-09026  
RISMAN, A A-00673  
ROCHELEAU, R F B-05570  
ROGUS, C A B-02153, \*B-02397, \*J-01294  
ROHR F W B-14613  
ROHRMAN, F A A-00943, \*A-07963  
ROLFE T J K B-16749  
ROMANEK W C-15533  
ROSE A H JR A-24767  
ROSE, A H JR A-00027, A-06086, B-02232  
ROSE, G A-08816  
ROSENBERG T B-20728  
ROSS R W K-14366  
ROUSSEAU H A-17552  
ROUSSEAU P E A-17552  
ROWE D R C-24412  
RUE P G L A-20276

## S

SABIS W R L-23765  
SABLESKI, J J B-09826, \*L-10491  
SABLESKI, J J JR B-06084  
SALKOWSKI, M J C-02260, \*C-02369  
SAMPLES R H B-19236  
SAROFIM A F A-22642, A-25220  
SATYANARAYANA R T R F-14370  
SCHIEMANN, G A-08583  
SCHMITZ, F W B-02400  
SCHOENBERGER, R J B-04843  
SCHUMANN C E C-19580  
SCHUMANN, C E C-01612, C-07077  
SCHWARTZ, C A-05465  
SCHWARTZ, D B-01943  
SCOTT D H A-14972, L-23765  
SEBASTIAN F P B-16730  
SEGELER, C G A-05815  
SETTI, B A-08577  
SHIRASAWA T B-23262  
SILVERMAN, L B-06315  
SIMON, H B-09789  
SIMONS W L-12989  
SMAUDER E E B-23542  
SMITH D B A-14972, L-23765  
SMITH R A A-14923  
SPAETH H I-14737  
STABENOW G B-14524  
STABENOW, G A-05494, \*B-01939,  
\*B-02398  
STAHL Q R A-17604, \*A-21991  
STEIGERWALD, B J A-07963  
STEINBACH, W A-08373, C-08257

# AUTHOR INDEX

81

STENBURG, R L A-06086, \*B-01064,  
\*B-01944, \*B-02186, \*B-02232  
STEPHENSON J W B-19597  
STEPHENSON, J W A-08850, \*B-02399,  
\*L-01948  
STERLING, M B-05874, \*M-06085  
STRATTON, M B-00582  
STREET R K B-19236  
STUMBAR, J P F-09284  
STUMPH T L L-12511  
STUTZ, C N B-02488  
SUGIMOTO N A-25056  
SULLIVAN R J A-20585  
SYROVATKA, Z B-03229

## T

TADA M B-14940  
TADA, H L-07202  
TALEJKINSKI W B-21435  
TAMORI Y B-23262  
TANNER R A-21492  
TANNER, R A-05878, \*A-11461  
TAYLOR H E B-13363  
TEBBENS, B D F-01798  
THOMAS K T B-23856

THOMAS, J F F-01798  
TRUITT, S M B-05852  
TRUSS H W A-25862  
TUTTLE, W N C-08675

## V

VANDAVEER F E B-23008  
VAUGHN, R D L-10454  
VELZY C O B-14061  
VENEZIA, R A L-11095  
VICKERSON, G L B-02402  
VOELKER E M K-22375  
VOELKER, E M A-02773, \*B-01938  
VOLK A B-21435  
VON LEHMDEN, D J A-01788, A-05005,  
B-02232  
VON WEIHE, A A-11412

## W

WAITKUS, J B-10455  
WALKER, A B B-01937, \*B-02400,  
\*B-05498  
WEGMAN, L S A-05495, \*B-01945

WEIAND H A-11940  
WEINTRAUB, M A-05465  
WEISBURD, M I B-00975  
WENE, A W B-02401  
WIKSTROM L L A-14923  
WILLIAMS, R E A-05520  
WILLIAMSON J E A-11803  
WILLIAMSON, J E B-06084, B-09823,  
B-09824, B-09826  
WISE, K R A-06370  
WOHLERS H C D-22812  
WOLF, M A-00712  
WOLFF, R A K-05197  
WOODRUFF P H B-14522  
WOODRUFF, P H B-02401  
WOOLRICH, P F A-05160  
WOTSCHKE, J A-11636  
WUHRMANN, K A A-11666

## Z

ZABODNY, S B-02394  
ZALMAN S B-25706  
ZANFT, A B A-10038  
ZANKL, W A-11429  
ZINN R E A-22860, A-22862, \*B-14612,  
B-22808



**BLANK PAGE**

# SUBJECT INDEX

## A

- ARATEMENT A-11803, C-24412, L-07202,  
L-07522, L-09677, L-09916, L-11095,  
L-12511, L-16343, L-20861, L-22466,  
L-23126, L-23765, M-15002, N-22326
- ABSORPTION B-08727, B-09784, B-12655,  
B-14613, B-21058, C-02369, C-21663,  
G-23167, L-08976
- ABSORPTION (GENERAL) B-18252
- ACETALDEHYDE F-01798
- ACETIC ACID A-09676, A-11649
- ACETONE A-09676
- ACETYLENES A-10424, C-08675
- ACID SMUTS A-25549
- ACIDS A-00673, A-00972, A-05815,  
A-07561, A-08583, A-08816, A-09026,  
A-09676, A-09686, A-09785, A-11438,  
A-11649, A-20646, A-22642, A-22862,  
A-24421, A-25549, A-25862, A-26204,  
B-00975, B-09784, B-09789, B-09823,  
B-09826, B-10694, B-14369, B-14967,  
B-16749, D-02833, D-22812, G-01941,  
H-09275, I-12055, I-19325, L-08976,  
L-09916
- ACROLEIN F-01798
- ADAPTATION G-23293
- ADHESIVES A-05718, C-01612, C-07077
- ADMINISTRATION A-05718, A-05815,  
A-07963, A-09785, A-11803, A-14923,  
A-22862, A-23313, A-23314, B-00975,  
B-01437, B-01938, B-01945, B-02394,  
B-07973, B-09789, B-10694, B-12664,  
B-14364, B-15544, C-04117, C-07077,  
D-00149, D-02833, D-03454, J-02392,  
L-02393, L-06961, L-07522, L-07879,  
L-08976, L-09677, L-09916, L-10454,  
L-10491, L-10567, L-11095, L-19059,  
L-23765, L-25480, L-25688, M-15002,  
N-00164
- ADSORPTION A-22540, B-09784, B-12655,  
B-14613, C-21663, L-08976
- ADSORPTION (GENERAL) A-22540
- ADVISORY SERVICES L-23126
- AERODYNAMICS A-11475, A-20906,  
A-23584, C-07077
- AEROSOLS A-07561, A-09785, B-00107,  
B-00975, B-09784, B-23856, B-26063,  
C-08257, C-17468, C-21663, N-00164
- AFTERBURNERS A-05718, A-07804,  
A-10418, A-20276, A-20759, A-22642,  
A-23584, B-01936, B-02186, B-05852,  
B-06084, B-07769, B-09784, B-09826,  
B-10455, B-12655, B-24089, B-25570,  
B-25977, F-09284, I-19325, L-08826,  
L-10491, L-11095, L-12989
- AIR CONDITIONING EQUIPMENT  
B-01938, B-12651
- AIR POLLUTION EPISODES M-15002
- AIR POLLUTION FORECASTING  
D-00149
- AIR QUALITY CRITERIA L-09514
- AIR QUALITY MEASUREMENT  
PROGRAMS A-23313, A-23314,  
C-04117, D-00149, D-02833, D-03454,  
L-25480, L-25688, N-00164
- AIR QUALITY MEASUREMENTS  
A-00673, A-00943, A-00972, A-01788,  
A-02414, A-03154, A-03870, A-05005,  
A-05160, A-05492, A-05815, A-06086,  
A-09785, A-10418, A-10424, A-10678,  
A-16254, A-20585, A-22860, A-22873,  
A-24013, B-00288, B-00968, B-00975,  
B-01947, B-02153, B-04843, B-06784,  
B-14967, B-16730, B-19896, B-21626,  
C-02391, C-04117, C-05834, C-07077,  
C-14368, C-15533, C-24412, D-02395,  
D-02833, D-03454, D-22812, I-19325,  
L-00973, L-03805, L-09500, L-09677,  
L-10567, L-19059, L-22466, L-25480,  
L-25688, N-00164, N-22326
- AIR QUALITY STANDARDS A-11461,  
A-11638, A-11649, A-25549, B-00288,  
B-00975, B-02153, B-02389, B-02390,  
L-00973, L-03805, L-07202, L-08826,  
L-09677, L-23126, M-24009, N-01531
- AIR RESOURCE MANAGEMENT  
L-09514, L-23765
- AIR-FUEL RATIO B-01935, B-06096,  
B-09823, B-20294, B-22821, B-23542
- AIRCRAFT A-00972, A-03154, A-09785,  
A-24013, A-25549, B-15544, D-03454,  
N-00164
- ALCOHOLS A-07561, A-09676, A-09785,  
B-04838, G-01941
- ALDEHYDES A-00673, A-00972, A-01788,  
A-05815, A-07561, A-09026, A-09686,  
A-09785, A-11649, A-20646, A-21991,  
B-00975, B-02153, B-02232, B-09826,  
B-10694, B-14967, B-23008, C-21663,  
D-02833, D-22812, F-01798, G-01941,  
L-08826
- ALERTS M-15002
- ALIPHATIC HYDROCARBONS A-00027,  
A-09676, A-09785, A-10424, B-04838,  
C-08675, F-01798, L-08826
- ALKALINE ADDITIVES A-23815
- ALLERGIES A-20585, G-01941
- ALTITUDE A-06370, A-25862
- ALUMINUM A-09686, B-00107, B-09784
- ALUMINUM COMPOUNDS A-05492,  
A-09785, B-01947, C-17352
- ALUMINUM OXIDES A-05492
- AMMONIA A-00673, A-00972, A-05815,  
A-07561, A-09686, A-09785, A-17610,  
A-20646, A-23815, B-07921, B-10694,  
B-14967, C-06095, D-02833, D-22812,  
G-01941, I-19325
- AMMONIUM COMPOUNDS A-00673,  
A-00972, A-05815, A-07561, A-09686,  
A-09785, A-17610, A-20646, A-23815,  
B-07921, B-10694, B-14967, C-06095,  
D-02833, D-22812, G-01941, I-19325,  
L-09916
- ANALYTICAL METHODS A-00027,  
A-01788, A-05005, A-05492, A-06086,  
A-08373, A-08583, A-08850, A-09676,  
A-10418, A-10424, A-11475, A-17604,  
A-17610, A-18009, A-21991, A-22540,  
B-00968, B-00975, B-01939, B-02027,  
B-02232, B-04843, B-05570, B-09823,  
B-09826, B-12651, B-12655, B-14967,  
B-22156, C-05834, C-08257, C-08675,  
C-17468, C-21663, C-24412, C-25696,  
D-02395, D-22812, F-01798, F-09284
- ANIMALS A-21991, G-23167, G-23293
- ANNUAL B-10694, J-11114, L-25480,  
L-25688
- ANTHRACENES A-01788, A-05005,  
A-10424, F-01798
- AREA EMISSION ALLOCATIONS  
L-08976, L-09677, L-23126
- AREA SURVEYS A-23313, A-23314,  
D-02833, D-03454, N-00164
- AROMATIC HYDROCARBONS A-01788,  
A-07561, A-09785, A-10424, A-23584,  
B-02389, F-01798, L-08826
- ARSENIC COMPOUNDS B-00975
- ARSINE B-00975
- ASBESTOS A-22873, B-24465
- ASHES A-05492, A-05497, A-09026,  
A-11411, A-11412, A-11427, A-11428,  
A-11430, A-11447, A-18173, A-23025,  
A-24421, B-00246, B-01946, B-02401,  
B-10009, B-13133, B-13363, B-14524,  
B-15201, B-22156, B-22757, D-02395
- ASIA A-14168, A-17243, A-17462, A-20646,  
A-22130, A-22540, A-24241, A-25056,  
B-14364, B-14940, B-15396, B-16137,  
B-16536, B-17403, B-21058, B-23262,  
B-23856, C-17468, I-19325, K-17201,  
L-07202, L-22466
- ASPHALT A-00972, A-05005, A-09686,  
A-09785, B-00107, B-02232, B-09784,  
L-09677, L-22466
- ASTHMA D-03454
- ATMOSPHERIC MOVEMENTS A-09785,  
A-10678, A-23313, B-00975, D-03454,  
G-23293, L-08976, L-09514, L-25480,  
L-25688, M-24009, N-22326
- AUSTRALIA A-10424, B-08632, B-16751
- AUTOMATIC METHODS A-10418,  
A-11963, B-00975, C-02260
- AUTOMOBILES A-05005, A-09686,  
A-09785, A-11803, B-00975, B-10694,  
D-00149, D-02833, G-23293, L-08976,  
L-19059, N-00164
- AUTOMOTIVE EMISSION CONTROL  
A-23313, A-23314, B-01935, B-06096,  
B-08837, B-09823, B-15544, B-20294,  
B-22821, B-23542, L-08976
- AUTOMOTIVE EMISSIONS A-00673,  
A-00972, A-05005, A-09686, A-09785,  
A-10424, A-17610, A-21991, A-22540,  
B-00975, B-08837, B-15544, C-08257,  
C-24412, D-02833, D-03454, D-22812,  
F-01798, G-23293, L-00973, L-08976,  
L-09500, L-09677, L-23765, N-00164

## B

- BACTERIA A-09676, D-22812
- BAFFLES A-05495, A-22862, A-23815,  
B-00968, B-02153, B-02399, B-02738,  
B-05498, B-07426, B-14522, B-19550,  
B-20728, B-25511, C-21663, J-02392

## MUNICIPAL INCINERATORS

BAG FILTERS A-02334, A-08850, A-10418, A-13112, A-17610, A-20585, A-22862, B-00107, B-01940, B-02153, B-02738, B-05498, B-06096, B-06315, B-08632, B-10455, B-11792, B-14365, B-19597, B-19896, B-23856, J-02392, K-14366  
 BARIUM COMPOUNDS A-09785  
 BASIC OXYGEN FURNACES A-09686, L-09677  
 BATTERY MANUFACTURING A-09785  
 BENZENE-SOLUBLE ORGANIC MATTER A-05005  
 BENZENES A-01788, A-07561, A-10424, F-01798  
 BENZO(3,4)PYRENE A-00972, A-01788, A-05005, A-10424, A-25549, F-01798, L-08976  
 BENZOPYRENES A-00972, A-01788, A-05005, A-10424, A-25549, F-01798, L-08976  
 BERYLLIOSIS A-00027, A-00673, A-00943, A-00972, A-01788, A-02414, A-03154, A-03870, B-00288, B-00968, B-00975, B-01937, B-01942, B-01946, B-01947, B-02153, B-02186, B-02232, C-01612, C-02260, C-02369, C-02391, D-00149, D-02395, D-02833, D-03454, F-01798, L-00973, L-02393, L-03805, N-00164  
 BERYLLIUM L-11095  
 BESSEMER CONVERTERS A-09686, L-09677  
 BETA PARTICLES C-02369  
 BIOCLIMATOLOGY G-23293  
 BLAST FURNACES A-09686, L-09677  
 BLOWBY N-00164  
 BODY CONSTITUENTS AND PARTS A-07561  
 BOILERS A-01788, A-03154, A-03155, A-03868, A-03870, A-05005, A-05160, A-05493, A-05494, A-05497, A-05878, A-06937, A-08577, A-08816, A-09158, A-11640, A-11968, A-11969, A-17552, A-22130, B-00107, B-01437, B-02398, B-09784, B-14369, B-15544, B-20294, I-12055, I-14737, J-01294, L-05496, L-06741, L-07202, L-09677, L-16343, L-20861  
 BRICKS A-07804, A-08850, B-09823, B-09826  
 BROMIDES A-09785  
 BROMINE COMPOUNDS A-09785, B-00975  
 BRONCHITIS G-23167  
 BUDGETS L-09916, L-11095, L-25480, L-25688  
 BUILDINGS A-02334, A-12441, B-02186, B-06096, B-06315, B-09784, B-09826, D-03454, H-09275, K-07595, L-07522, L-09514, L-11095  
 BUSES B-00975, D-00149, L-08976, N-00164  
 BUTADIENES A-10424, F-01798  
 BUTANES A-10424, C-08675, F-01798  
 BUTENES A-10424, C-08675, F-01798  
 BUTYRALDEHYDES F-01798  
 BY-PRODUCT RECOVERY A-08577, A-09663, A-17552, A-22860, A-23025, B-07769, B-07921, B-10694, B-11792, B-12651, B-14524, B-14940, B-16730, B-19597, B-22296, B-25977, B-26063

## C

CADMIUM COMPOUNDS G-23167  
 CALCIUM COMPOUNDS A-09676, A-09785, B-01947

CALIBRATION METHODS C-08257, C-08675  
 CALIFORNIA A-03154, A-05160, A-06852, A-09785, A-11638, A-12441, A-24013, B-00107, B-00288, B-00975, B-07973, B-09784, L-00973, L-03805, L-08826, L-09677, N-00164  
 CANADA A-03154, A-03155, A-21492, A-23025, B-00975, B-01943, B-01946, B-02232, B-02388, C-02260, C-02369, C-02391, D-03454, L-02393  
 CANCER A-17604, A-20585, G-01941  
 CARBIDES D-02395  
 CARBON BLACK A-05005, A-05492, A-09676, A-10424, A-22540, B-09789  
 CARBON DIOXIDE A-01788, A-05465, A-05492, A-05718, A-06086, A-07561, A-08373, A-09026, A-09676, A-10418, A-10678, A-14923, A-20276, B-00975, B-01935, B-01947, B-02232, B-02389, B-06084, B-07426, B-07921, B-14522, B-16730, D-00149, D-22812, G-01941, L-09677  
 CARBON MONOXIDE A-00027, A-00972, A-01788, A-05465, A-05718, A-05969, A-06086, A-07561, A-08373, A-09026, A-09676, A-09686, A-09785, A-11803, A-14923, A-19052, A-22540, A-22642, A-22862, A-24013, B-00107, B-00975, B-02153, B-02232, B-07426, B-09784, B-10694, B-14522, B-20294, C-02260, C-04117, C-21663, C-25696, D-22812, G-01941, G-23293, L-08976, L-09916, N-00164, N-22326  
 CARBON TETRACHLORIDE B-04838, L-09916  
 CARBONATES A-09676, D-02395  
 CARBONYLS A-09026, G-23167, L-09677  
 CARBURETOR EVAPORATION LOSSES L-09677  
 CARCINOGENS A-00673, A-00943, A-00972, A-02414, A-10424, B-00288, B-00968, B-00975, B-01937, B-02153, B-02402, C-01612, C-02391, D-00149, D-02833, D-03454, L-00973, N-00164  
 CARDIOVASCULAR DISEASES G-23167  
 CASCADE SAMPLERS B-00975  
 CATALYSIS A-00972, A-05005, B-23008, I-12055  
 CATALYSTS B-23008  
 CATALYTIC ACTIVITY A-00972  
 CATALYTIC AFTERBURNERS A-07804, B-07769, L-08826  
 CATALYTIC OXIDATION A-05815, B-23008  
 CEMENTS A-00972, A-07804, B-09784, B-09789, L-22466  
 CENTRIFUGAL SEPARATORS A-02334, A-05005, A-05495, A-05878, A-09158, A-09686, A-17462, A-19547, A-22130, A-22862, A-24421, A-25056, B-02027, B-02153, B-02186, B-02399, B-02402, B-05498, B-07426, B-07769, B-08632, B-08727, B-10455, B-13133, B-13697, B-14736, B-15201, B-19987, B-23482, C-21663, K-22389  
 CERAMICS A-05492, A-09686, A-11450, B-00107  
 CHAMBER PROCESSING A-17610, B-18252  
 CHARCOAL A-09676  
 CHEMICAL COMPOSITION A-03870, A-05005, A-05492, A-05815, A-10418, A-16254, B-01947, B-02153, B-04843, D-03454, I-19325  
 CHEMICAL METHODS A-00027, B-04843, B-12655, C-25696, D-02395, D-22812

CHEMICAL PROCESSING A-00972, A-03154, A-05005, A-07963, A-09686, A-09785, A-11448, A-17604, A-17610, A-22540, A-24013, A-26204, B-00107, B-00975, B-05569, B-05570, B-07769, B-08178, B-09784, B-09789, B-14940, B-18252, B-25977, C-17468, C-21663, D-03454, I-24187, L-11095, M-14805  
 CHEMICAL REACTIONS A-07639, A-08850, A-09676, A-09785, A-11475, A-21991, A-22642, A-22862, A-23584, A-26204, B-04838, B-07921, B-25977, C-24412, D-03454, F-01798, I-12055  
 CHICAGO L-00973, L-09677, L-11095, M-14805  
 CHLORIDES A-09785, A-25220, I-14737, I-16420  
 CHLORINATED HYDROCARBONS A-09785, A-25862, B-04838, L-08826, L-09916  
 CHLORINE A-00712, A-09686, A-09785, A-25862, B-02390, D-22812, H-09275, I-12055, L-09916  
 CHLORINE COMPOUNDS A-09785, A-11438, A-11651, A-25220, B-00975, B-16749, H-09275, I-14737, I-16420  
 CHLOROFORM L-09916  
 CHROMATOGRAPHY A-01788, A-05005, A-05492, A-06086, A-08373, A-08850, A-09676, A-10424, A-11475, A-18009, B-02027, B-02232, B-05570, B-09823, B-09826, B-12655, B-22156, C-05834, C-08257, C-08675, C-21663, F-01798, F-09284  
 CHROMIUM I-24187  
 CHROMIUM COMPOUNDS A-09785  
 CHROMIUM OXIDES A-09026  
 CHRYSENES F-01798  
 CINCINNATI C-01612, C-07077, D-00149, L-00973, L-09677, L-25480, L-25688  
 CINDERS A-11447, A-25862, B-22757, L-07202  
 CITIZENS GROUPS B-00975  
 CITY GOVERNMENTS A-06852, A-12441, J-03006, L-07522, L-08826, L-08976, L-09514, L-19059, M-15002, N-01531  
 CLEAN AIR ACT B-08632, L-08826, L-09916, L-11095, L-20861, L-23765  
 COAL A-00673, A-00943, A-01788, A-05005, A-05494, A-07963, A-09158, A-09686, A-10424, A-10678, A-11411, A-11447, A-11803, A-11968, A-23314, B-23262, C-17468, D-00149, D-22812, J-11114, L-00973, L-09916, L-11095  
 COAL PREPARATION A-18173  
 COAL TARS A-10424, A-25549  
 CODES A-05718, A-07804, A-10675, B-01938, B-02400, L-09916, L-10491, L-18108  
 COFFEE-MAKING A-00972, A-09686, B-00246  
 COKE A-00943, A-05005, A-11447, A-25549, B-08178, L-06961, L-09677  
 COLLECTORS A-00972, A-02334, A-05005, A-05495, A-05878, A-08850, A-09158, A-09686, A-17462, A-19547, A-20646, A-22130, A-22862, A-23815, A-24421, A-25056, B-00968, B-01437, B-01935, B-01938, B-01940, B-01947, B-02027, B-02153, B-02186, B-02387, B-02398, B-02399, B-02400, B-02402, B-02738, B-02976, B-05498, B-05852, B-06084, B-07426, B-07769, B-08632, B-08727, B-08837, B-09784, B-10009, B-10455, B-12651, B-12655, B-13133, B-13697, B-14365, B-14522, B-14736, B-15201, B-16137, B-19550, B-19896, B-19987,



# SUBJECT INDEX

85

- B-20728, B-22296, B-23482, B-23542,  
B-24954, B-25511, C-02260, C-21663,  
J-02392, K-22389, L-08976
- COLORIMETRY** A-00027, A-17604,  
A-17610, A-21991, A-22540, B-02232,  
C-17468, C-21663, C-24412, D-22812
- COLUMN CHROMATOGRAPHY** A-01788,  
A-05005, C-05834, F-01798
- COMBUSTION** A-00027, A-01788, A-05005,  
A-05465, A-05492, A-05520, A-07206,  
A-08090, A-09663, A-09671, A-10675,  
A-11427, A-11428, A-11430, A-11447,  
A-11475, A-11939, A-17552, A-20906,  
A-21492, A-22642, A-24241, A-25056,  
A-25862, A-26204, B-00183, B-01935,  
B-01936, B-01947, B-02388, B-02389,  
B-02390, B-02394, B-02396, B-02397,  
B-02400, B-02401, B-02402, B-04843,  
B-05852, B-06588, B-07769, B-07921,  
B-09823, B-09826, B-10009, B-10694,  
B-12080, B-19236, B-20730, B-22757,  
B-23819, B-23836, B-24954, B-25977,  
F-01798, F-09284, F-13618, F-14370,  
J-02392, L-02393, L-03805, L-06741,  
L-07879, L-09677, L-11095
- COMBUSTION AIR** A-02334, A-05465,  
A-05492, A-05493, A-05878, A-05969,  
A-06086, A-07561, A-09026, A-09663,  
A-09671, A-10418, A-10433, A-11447,  
A-14367, A-20153, A-20737, A-22642,  
A-22862, A-24767, A-25220, B-01064,  
B-01935, B-01936, B-01938, B-01947,  
B-02232, B-02396, B-02398, B-04838,  
B-05498, B-05852, B-06096, B-06315,  
B-06588, B-07426, B-07769, B-08178,  
B-08837, B-09823, B-09826, B-10009,  
B-12080, B-14612, B-15396, B-16536,  
B-22757, B-22821, B-22822, B-23542,  
B-23836, F-01798, I-19325
- COMBUSTION GASES** A-00027, A-00673,  
A-01788, A-02414, A-05005, A-05160,  
A-05465, A-05651, A-05718, A-06086,  
A-07206, A-07561, A-07804, A-07963,  
A-08577, A-08583, A-08816, A-09026,  
A-09663, A-09671, A-09686, A-09785,  
A-10418, A-10424, A-10433, A-10678,  
A-11411, A-11412, A-11413, A-11427,  
A-11428, A-11429, A-11430, A-11431,  
A-11432, A-11438, A-11439, A-11447,  
A-11461, A-11636, A-11638, A-16254,  
A-17610, A-18009, A-18173, A-20737,  
A-21952, A-22540, A-22642, A-22860,  
A-23815, A-24421, A-25549, A-25862,  
A-26204, B-00107, B-00183, B-00246,  
B-00288, B-01437, B-01935, B-01937,  
B-01947, B-02153, B-02186, B-02232,  
B-02387, B-02390, B-02398, B-03229,  
B-06084, B-06096, B-06315, B-08178,  
B-08632, B-08837, B-09784, B-09823,  
B-09824, B-09826, B-10009, B-13133,  
B-13363, B-14061, B-14369, B-14613,  
B-15201, B-16137, B-17403, B-19597,  
B-19896, B-20773, B-21058, B-21626,  
B-22296, B-22757, B-23262, B-23836,  
B-24465, B-25511, B-25706, C-02260,  
C-02391, C-04117, C-05834, C-06095,  
C-08257, C-08675, C-14368, C-15533,  
C-24412, C-25696, D-02395, D-22812,  
G-01941, H-09275, I-12055, I-14737,  
I-19325, J-02392, J-11114, K-14366,  
K-22375, K-22389, L-02393, L-07202,  
L-07522, L-08976, L-09677, L-10491,  
L-10567, L-12989, L-16343, L-22466,  
M-24009
- COMMERCIAL AREAS** A-05815, A-08850,  
B-06096, B-09823, L-07522, L-08976,  
L-09514, L-09677, L-10567
- COMMERCIAL EQUIPMENT** A-11448,  
B-00107, B-00246, B-00975, B-02153,  
B-02402, B-12651, B-14612, B-16751,  
J-01294
- COMMERCIAL FIRMS** B-07973, C-04117,  
L-01948
- COMPLAINTS** A-14972, B-00975, M-14805
- COMPOSTING** A-00712, A-08850, A-09676,  
A-11651, A-11940, A-17243, A-18009,  
A-19052, B-02741, B-07973, B-11792,  
L-23126
- COMPRESSION** B-22296
- COMPUTER PROGRAMS** A-16254
- CONCRETE** A-09686, A-11971, B-00107,  
B-09784
- CONDENSATION** B-14613, B-19236
- CONDENSATION (ATMOSPHERIC)**  
A-10678
- CONNECTICUT** D-03454
- CONSTRUCTION MATERIALS** A-00972,  
A-05005, A-05492, A-07804, A-08816,  
A-08850, A-09676, A-09686, A-09785,  
A-11450, A-11971, A-18009, B-00107,  
B-00975, B-02232, B-09784, B-09789,  
B-09823, B-09824, B-09826, I-24187,  
L-09677, L-22466
- CONTACT PROCESSING** A-22540,  
B-18252
- CONTINUOUS AIR MONITORING  
PROGRAM (CAMP)** D-00149
- CONTINUOUS MONITORING** A-05005,  
B-02232, B-02388, B-08727, B-10009,  
C-08257, C-17468
- CONTROL AGENCIES** A-05718, B-07973,  
D-03454, L-11095, L-19059, M-15002,  
M-24009
- CONTROL EQUIPMENT** A-00972,  
A-02334, A-02773, A-03155, A-03868,  
A-05005, A-05492, A-05495, A-05651,  
A-05718, A-05878, A-06937, A-07206,  
A-07804, A-08583, A-08816, A-08850,  
A-09158, A-09663, A-09676, A-09686,  
A-10038, A-10418, A-11411, A-11413,  
A-11428, A-11431, A-11432, A-11450,  
A-11638, A-11640, A-11647, A-11651,  
A-11969, A-13112, A-13622, A-16514,  
A-17462, A-17552, A-17604, A-17610,  
A-18009, A-18173, A-19547, A-20276,  
A-20585, A-20646, A-20759, A-21882,  
A-22130, A-22540, A-22642, A-22860,  
A-22862, A-23025, A-23584, A-23815,  
A-24421, A-25056, A-25220, A-25862,  
A-26204, B-00107, B-00183, B-00288,  
B-00582, B-00968, B-00975, B-01064,  
B-01437, B-01935, B-01936, B-01937,  
B-01938, B-01939, B-01940, B-01947,  
B-02027, B-02153, B-02186, B-02387,  
B-02390, B-02398, B-02399, B-02400,  
B-02401, B-02402, B-02488, B-02738,  
B-02976, B-03229, B-05498, B-05569,  
B-05570, B-05852, B-06084, B-06096,  
B-06315, B-06588, B-07426, B-07769,  
B-07921, B-08632, B-08727, B-08837,  
B-09784, B-09789, B-09824, B-09826,  
B-10009, B-10455, B-11652, B-11658,  
B-11792, B-12651, B-12655, B-13133,  
B-13363, B-13697, B-14061, B-14364,  
B-14365, B-14369, B-14522, B-14613,  
B-14736, B-14940, B-15201, B-16137,  
B-17403, B-18252, B-19550, B-19597,  
B-19896, B-19987, B-20728, B-20730,  
B-21058, B-21435, B-22156, B-22296,  
B-22757, B-22808, B-23262, B-23482,  
B-23542, B-23856, B-24089, B-24465,  
B-24954, B-25511, B-25570, B-25706,  
B-25977, B-26063, C-02260, C-02369,  
C-04117, C-15533, C-20808, C-21663,  
D-22812, F-09284, I-19325, I-24187,  
J-01294, J-02392, J-03006, J-11114,  
K-14366, K-22389, L-06741, L-08826,  
L-08976, L-09916, L-10491, L-10567,  
L-11095, L-12989, L-18108
- CONTROL METHODS** A-00027, A-00712,  
A-02009, A-02334, A-02414, A-02773,  
A-03155, A-03868, A-03870, A-05465,  
A-05492, A-05493, A-05494, A-05495,  
A-05520, A-05815, A-05878, A-05969,  
A-06086, A-06852, A-07206, A-07561,  
A-08577, A-08583, A-08850, A-09026,  
A-09663, A-09671, A-09676, A-09686,  
A-10038, A-10418, A-10433, A-10675,  
A-11432, A-11447, A-11651, A-11803,  
A-11968, A-14367, A-14442, A-16710,  
A-17552, A-17610, A-18009, A-18173,  
A-20153, A-20276, A-20737, A-21492,  
A-21952, A-22540, A-22642, A-22860,  
A-22862, A-23025, A-23313, A-23314,  
A-23815, A-24421, A-24767, A-25056,  
A-25220, A-26204, B-00107, B-00183,  
B-00246, B-00288, B-00975, B-01064,  
B-01935, B-01936, B-01937, B-01938,  
B-01940, B-01944, B-01947, B-02153,  
B-02232, B-02387, B-02388, B-02389,  
B-02390, B-02394, B-02396, B-02397,  
B-02398, B-02399, B-02400, B-02401,  
B-02402, B-02741, B-02976, B-03229,  
B-04838, B-05498, B-05569, B-05570,  
B-05852, B-05874, B-06084, B-06096,  
B-06315, B-06588, B-07426, B-07769,  
B-07921, B-07973, B-08178, B-08632,

## MUNICIPAL INCINERATORS

## D

B-08727, B-08837, B-09784, B-09789,  
B-09823, B-09826, B-10009, B-10455,  
B-10694, B-11792, B-12080, B-12651,  
B-12655, B-14364, B-14365, B-14369,  
B-14522, B-14524, B-14612, B-14613,  
B-14940, B-15396, B-15544, B-16536,  
B-16730, B-16749, B-17403, B-18252,  
B-19550, B-19597, B-20294, B-20728,  
B-20773, B-21058, B-21626, B-22296,  
B-22757, B-22808, B-22821, B-22822,  
B-23008, B-23542, B-23819, B-23836,  
B-25977, B-26063, C-02260, C-02369,  
C-02391, C-21663, D-02395, F-01798,  
G-23167, I-19325, I-24187, J-01294,  
J-02392, J-03006, J-11114, K-07595,  
L-00973, L-02393, L-08826, L-08976,  
L-09916, L-18108  
CONTROL PROGRAMS A-05718, A-07963,  
A-09785, B-00975, B-01437, B-07973,  
B-10694, D-02833, L-06961, L-07522,  
L-09677, L-09916, L-10491, L-10567,  
L-11095, L-19059, L-23765, L-25480,  
L-25688, M-15002  
CONTROLLED ATMOSPHERES C-21663,  
D-22812  
CONVECTION F-14370  
COOLING A-03870, A-05495, A-05651,  
A-09663, A-10418, A-23815, B-01935,  
B-09824, B-09826, B-10009, B-14613,  
B-20773, B-24089, C-08675  
COPPER A-09686, B-00107  
COPPER ALLOYS B-00107  
COPPER COMPOUNDS A-09785  
CORE OVENS B-00107, B-09784  
CORONA B-09789  
CORROSION A-03868, A-08816, A-17610,  
B-14369, B-15201, I-12055, I-14737,  
I-16420, I-19325, I-24187, K-14366  
COSTS A-02414, A-02773, A-03868,  
A-05493, A-05494, A-05497, A-05969,  
A-07206, A-08577, A-09158, A-09663,  
A-09676, A-10418, A-11430, A-11962,  
A-13622, A-14442, A-16869, A-17552,  
A-18009, A-19547, A-22860, A-22862,  
A-25220, A-25862, B-00183, B-00582,  
B-01437, B-01937, B-01945, B-02153,  
B-02387, B-02388, B-02390, B-02397,  
B-02738, B-07921, B-08632, B-09789,  
B-10009, B-14365, B-14613, B-16730,  
B-19896, B-19987, B-22296, B-22757,  
B-22808, B-23856, B-24954, J-01294,  
J-02392, J-03006, J-11114, J-11857,  
K-22375, L-02393, L-05496, L-07522,  
L-18108, L-25480, L-25688  
COUNTY GOVERNMENTS A-12441,  
A-23313, A-23314, B-00107, B-09784,  
L-08826, L-09677, L-23765  
CRANKCASE EMISSIONS L-09677,  
N-00164  
CRITERIA A-02334, A-10675, A-12441,  
A-16514, A-22862, B-02387, B-02388,  
B-02389, B-02390, B-02394, B-02396,  
B-02398, B-02399, B-02400, B-02401,  
B-02402, B-07921, B-14365, B-14524,  
B-14612, C-02391, D-02395, J-02392,  
K-05197, K-07595, K-12118, K-17201,  
L-00973, L-01948, L-02393, L-09514,  
L-09677  
CROPS A-05492, N-00164  
CUPOLAS B-00107, L-09677, L-22466  
CZECHOSLOVAKIA A-00027, A-01788,  
A-02334, A-03870, B-00975, B-01935,  
B-01942, B-02232, B-02396, C-02369,  
D-00149, D-03454, F-01798, L-02393

DATA ANALYSIS A-14972, J-11114  
DATA HANDLING SYSTEMS A-14972,  
A-16254, B-00975, J-11114  
DECOMPOSITION B-07921  
DEGREASING A-09785, B-09784  
DENSITY A-05497, A-10424, A-11475,  
B-01935, F-14370  
DESIGN CRITERIA A-02334, A-03868,  
A-05520, A-07206, A-07804, A-08850,  
A-09158, A-10675, A-11430, A-11636,  
A-11647, A-11657, A-11934, A-11939,  
A-11940, A-11961, A-11962, A-11963,  
A-11969, A-11972, A-12441, A-13622,  
A-14168, A-14367, A-16254, A-16514,  
A-16710, A-16869, A-17462, A-17552,  
A-19052, A-19547, A-20153, A-20276,  
A-20646, A-20737, A-20759, A-20906,  
A-21492, A-21952, A-22130, A-22642,  
A-22860, A-23025, A-23584, A-24767,  
A-25056, A-25220, A-26204, B-00582,  
B-00968, B-01935, B-01936, B-01938,  
B-01939, B-01942, B-01943, B-01944,  
B-01945, B-02186, B-02232, B-02387,  
B-02389, B-02390, B-02394, B-02396,  
B-02397, B-02398, B-02399, B-02400,  
B-02401, B-02402, B-04838, B-06096,  
B-06315, B-06588, B-07921, B-09784,  
B-09789, B-09823, B-09824, B-09826,  
B-13133, B-14364, B-14365, B-14369,  
B-14522, B-14524, B-14612, B-15201,  
B-15396, B-16751, B-17275, B-18252,  
B-19236, B-19896, B-19941, B-20078,  
B-20294, B-20728, B-20730, B-21058,  
B-21435, B-21626, B-22296, B-22808,  
B-22821, B-22822, B-23542, B-23836,  
B-23856, B-24089, B-24954, B-25511,  
B-25570, B-25706, C-02260, C-02369,  
C-08675, C-20808, C-25696, D-02395,  
I-24187, J-01294, J-02392, J-03006,  
K-05197, K-07595, K-12118, K-22375,  
K-22389, L-01948, L-06741, L-07879,  
L-10491, M-06085  
DESULFURIZATION OF FUELS A-18173  
DETERGENT MANUFACTURING  
A-08850, B-09784  
DETROIT B-05874, L-00973, L-09677  
DIESEL ENGINES A-00673, A-03154,  
A-05005, A-09686, A-10424, A-11803,  
A-24013, B-08837, B-15544, D-00149,  
D-02833, L-08976, L-09916, N-00164  
DIFFRACTION I-14737  
DIFFUSION D-00149, L-25480, L-25688  
DIFFUSION MODELS L-25480, L-25688  
DIGESTERS A-22130  
DIGESTIVE SYSTEM A-17604, G-23293  
DIOLEFINS A-10424, C-08675, F-01798  
DISPERSION A-11450, A-14972, A-22130,  
B-00975, B-04838, D-00149, L-08976,  
L-25480, L-25688  
DISPERSIONS A-03155  
DISTILLATE OILS A-00673, A-09676  
DIURNAL D-00149, L-25688, N-00164  
DOMESTIC HEATING A-01788, A-02009,  
A-05005, A-07804, A-08577, A-09785,  
A-11413, A-17604, A-25549, D-03454,  
F-01798, L-07522, L-08976, L-09514,  
L-16343, L-18108, M-14805  
DONORA L-10567  
DROPLETS A-09785, A-11432  
DRUGS I-24187  
DRY CLEANING A-00972, A-09785,  
B-09784, L-09916, L-19059  
DRY CLEANING SOLVENTS L-09916

DRYING A-11428, A-11432, B-14364,  
B-18252  
DUMPS A-00673, A-01788, A-08850,  
A-14442, A-18009, A-19052, A-23313,  
A-23314, B-07973, B-10694, L-10454,  
L-23126, L-23765, N-00164, N-01531  
DUST FALL B-00975, C-14368, C-24412,  
D-22812, L-25688  
DUSTS A-05005, A-07804, A-08583,  
A-09671, A-09785, A-10418, A-10433,  
A-10678, A-11429, A-11461, A-13112,  
A-13622, A-17552, A-20646, A-21882,  
A-24421, A-25056, B-00968, B-01437,  
B-01935, B-01937, B-01939, B-01940,  
B-01947, B-02027, B-02387, B-02390,  
B-02397, B-02398, B-02976, B-06096,  
B-07426, B-08727, B-08837, B-09784,  
B-09789, B-10009, B-11658, B-11792,  
B-13363, B-13697, B-14364, B-14365,  
B-14369, B-14736, B-16137, B-17403,  
B-18252, B-21626, B-22156, B-23262,  
B-23482, B-23542, B-26063, C-04117,  
C-17352, C-17468, D-03454, H-09275,  
K-14366, K-22389, L-02393, L-06961,  
L-07202, L-08976, L-09677, L-12989,  
L-16343, L-19059, L-20133, L-22466,  
N-01531

## E

ECONOMIC LOSSES B-00975, B-01437,  
D-03454  
ELECTRIC CHARGE B-09789  
ELECTRIC FURNACES A-09686, B-00107  
ELECTRIC POWER PRODUCTION  
A-00943, A-00972, A-01788, A-03868,  
A-05005, A-05160, A-05494, A-06937,  
A-07206, A-07963, A-09663, A-09785,  
A-10038, A-10424, A-10678, A-11411,  
A-11413, A-11438, A-11448, A-11637,  
A-11640, A-11655, A-11803, A-11968,  
A-14972, A-25549, B-00107, B-00975,  
B-02397, B-02398, B-08837, B-09784,  
B-09789, B-10009, B-10694, B-15544,  
B-19941, B-24954, B-26063, C-06095,  
C-17468, C-21663, C-24412, D-02833,  
D-03454, D-22812, J-11114, J-11857,  
L-09514, L-09916, L-18108, L-23765,  
L-25688, N-00164, N-22326  
ELECTRIC PROPULSION L-09916  
ELECTRICAL MEASUREMENT DEVICES  
C-02369  
ELECTRICAL PROPERTIES B-09789,  
C-08257  
ELECTRICAL RESISTANCE B-09789  
ELECTRICITY (ATMOSPHERIC) G-23293  
ELECTROCHEMICAL METHODS  
C-25696, D-22812  
ELECTROCONDUCTIVITY ANALYZERS  
C-17468  
ELECTRON MICROSCOPY A-05969  
ELECTROSTATIC PRECIPITATORS  
A-00972, A-02334, A-03868, A-05005,  
A-05878, A-06937, A-07206, A-08583,  
A-09686, A-10038, A-11411, A-11413,  
A-11431, A-11638, A-11640, A-11647,  
A-13622, A-17462, A-17552, A-17604,  
A-19547, A-20585, A-21882, A-22130,  
A-22540, A-22860, A-22862, A-23025,  
B-00107, B-01437, B-01935, B-01937,  
B-01939, B-01940, B-02027, B-02153,  
B-02387, B-02390, B-02402, B-02738,  
B-03229, B-05498, B-08632, B-08837,  
B-09784, B-09789, B-10455, B-11792,  
B-12655, B-13697, B-14061, B-14364,



# SUBJECT INDEX

87

B-14365, B-14369, B-14613, B-14736,  
B-15201, B-17403, B-19597, B-19896,  
B-19987, B-22156, B-22296, B-23482,  
B-26063, C-21663, J-02392, K-14366,  
K-22369, L-08976

EMISSION INVENTORIES A-00673,  
A-00972, A-03154, A-05160, A-22860,  
A-22873, A-24013, B-00968, B-00975,  
B-16730, D-02833, L-25480, L-25688

EMISSION STANDARDS A-01788,  
A-05718, A-07804, A-08583, A-10675,  
A-19052, A-21882, A-22862, B-00288,  
B-01939, B-02390, B-02400, B-02401,  
B-08632, B-14365, B-14369, B-21626,  
C-08675, J-01294, K-14366, L-00973,  
L-02393, L-06961, L-09500, L-09677,  
L-10491, L-10567, L-20861, L-22466,  
L-25480, L-25688

EMISSIVITY F-01798

EMPHYSEMA G-01941, G-23167

ENFORCEMENT PROCEDURES B-00975,  
C-11088, L-09916, L-23765

ENGINE DESIGN MODIFICATION  
L-08976

ENGINE EXHAUSTS A-05005, A-09686,  
A-10424, B-15544, C-08257, D-03454,  
L-09677, N-00164

ENGINE OPERATING CYCLES A-05160,  
C-08257, N-00164

ENGINE OPERATION MODIFICATION  
B-01935, B-06096, B-09823, B-20294,  
B-22821, B-23542, L-08976

ENGINEERS B-08837, L-20061

EQUIPMENT CRITERIA A-02334,  
A-12441, A-16514, B-02396, B-02398,  
B-02399, B-02401, B-02402, B-07921,  
B-14365, B-14524, B-14612, C-02391,  
D-02395, K-05197, K-07595, K-12118,  
K-17201, L-01948

EQUIPMENT STANDARDS A-07804,  
A-12441, A-16514, B-01942, B-02389,  
B-02396, B-02400, B-14364, B-16751,  
B-21626, D-02395, K-12118, K-17201,  
K-22375, K-22389, L-19059

ESTERS A-07561, G-01941

ETHYL ALCOHOL A-09676

ETHYLENE C-08675

EUROPE A-00027, A-00712, A-00972,  
A-01788, A-02009, A-02334, A-03155,  
A-03868, A-03870, A-05494, A-05878,  
A-06937, A-07206, A-07659, A-08373,  
A-08577, A-08583, A-08816, A-08850,  
A-10038, A-10418, A-10424, A-10678,  
A-11411, A-11412, A-11413, A-11427,  
A-11428, A-11429, A-11430, A-11431,  
A-11432, A-11438, A-11439, A-11440,  
A-11447, A-11448, A-11449, A-11450,  
A-11461, A-11636, A-11637, A-11640,  
A-11647, A-11649, A-11651, A-11655,  
A-11657, A-11666, A-11934, A-11939,  
A-11940, A-11961, A-11962, A-11963,  
A-11968, A-11969, A-11971, A-11972,  
A-13112, A-13622, A-14442, A-17552,  
A-18173, A-21492, A-21882, A-24421,  
A-25549, A-25862, B-00183, B-00975,  
B-01935, B-01936, B-01939, B-01942,  
B-01947, B-02153, B-02232, B-02387,  
B-02388, B-02389, B-02390, B-02394,  
B-02396, B-02397, B-02398, B-02400,  
B-02401, B-02402, B-02976, B-03229,  
B-06588, B-08178, B-08632, B-08727,  
B-11652, B-11658, B-13697, B-14369,  
B-14524, B-14736, B-16730, B-20773,  
B-21435, B-21626, B-22156, B-23482,  
B-24465, B-26063, C-02369, C-08257,  
C-23437, D-00149, D-03454, F-01798,

G-23293, H-09275, I-14737, I-16420,  
J-01294, J-02392, K-22389, L-02393,  
L-03805, L-08976, L-12989, L-16343,  
L-20133, L-23126, N-22326

EVAPORATORS B-07769, B-23819

EXCESS AIR A-05465, A-05492, A-05493,  
A-05878, A-05969, A-06086, A-10433,  
A-11447, A-14367, B-01935, B-01936,  
B-01947, B-02232, B-02396, B-02398,  
B-04838, B-05498, B-05852, B-06096,  
B-07426, B-09823, B-10009, B-16536,  
B-23836, I-19325

EXHAUST SYSTEMS A-05651, A-10418,  
A-20759, B-07921, B-09784, B-09824,  
B-12651, B-20728, B-21058, B-23262,  
C-21663, I-24187

EXPERIMENTAL EQUIPMENT A-05465,  
A-07659, A-11475, A-20906, B-00582,  
B-01935, B-01937, C-15533

EXPERIMENTAL METHODS A-02334,  
A-05465, A-05718, A-20906, B-01942,  
B-02232, B-06096

EXPOSURE CHAMBERS A-10424

EYE IRRITATION A-17604, A-21991

## F

FANS (BLOWERS) A-05651, A-10418,  
A-20759, B-09784, B-09824, B-21058,  
B-23262

FEASIBILITY STUDIES J-11114, J-11857

FEDERAL GOVERNMENTS A-05718,  
A-16514, A-21882, B-07973, B-14364,  
C-11088, L-09500, L-10454, L-10491,  
L-11095, L-16343, L-23126

FERTILIZER MANUFACTURING A-17610

FIELD TESTS A-01788, A-03870, B-00975,  
B-01942, B-02396, B-07426, B-14522,  
B-22757, B-23008, L-02393, L-10491

FILTER FABRICS A-05005, A-05492,  
A-08816, A-08850, A-09676, A-09686,  
A-10418, A-11450, A-17610, A-18009,  
B-00107, B-02153, B-02186, B-06315,  
B-08632, B-08727, B-08837, B-09784,  
B-14365, B-19987, B-23856, B-24465,  
D-22812

FILTERS A-00972, A-02334, A-05005,  
A-05492, A-08816, A-08850, A-09676,  
A-09686, A-10418, A-11450, A-11638,  
A-11969, A-13112, A-17610, A-18009,  
A-19547, A-20585, A-22540, A-22862,  
A-23815, B-00107, B-01940, B-02153,  
B-02186, B-02402, B-02738, B-03229,  
B-05498, B-06096, B-06315, B-08632,  
B-08727, B-08837, B-09784, B-10455,  
B-11658, B-11792, B-12651, B-12655,  
B-14365, B-19597, B-19896, B-19987,  
B-21435, B-23262, B-23856, B-24465,  
B-26063, C-04117, C-20808, C-21663,  
D-22812, J-02392, K-14366, L-08976

FIRING METHODS A-02334, A-03155,  
A-03868, A-03870, A-05465, A-05492,  
A-05493, A-05494, A-05495, A-05520,  
A-05878, A-05969, A-06086, A-07561,  
A-09026, A-09663, A-09671, A-10418,  
A-10433, A-10675, A-11447, A-11968,  
A-14367, A-20153, A-20737, A-21952,  
A-22642, A-22862, A-24421, A-24767,  
A-25220, B-01064, B-01935, B-01936,  
B-01938, B-01944, B-01947, B-02232,  
B-02396, B-02398, B-02400, B-04838,  
B-05498, B-05852, B-06084, B-06096,  
B-06315, B-06588, B-07426, B-07769,  
B-07921, B-08178, B-08837, B-09823,  
B-09826, B-10009, B-12080, B-14612,

B-15396, B-16536, B-22757, B-22821,  
B-22822, B-23542, B-23819, B-23836,  
F-01798, I-19325

FLAME AFTERBURNERS A-07804,  
A-20276, A-20759, A-22642, A-23584,  
B-05852, B-06084, B-09826, B-10455,  
B-25570, F-09284, L-10491

FLAME IONIZATION DETECTOR  
A-08373, C-05834, C-08257

FLORIDA A-14972, K-14366, L-00973,  
L-09677, L-23765

FLOW RATES A-05465, A-05718, A-10418,  
A-25220, B-01935, B-06084, B-09789,  
B-22757, B-22822, B-23262

FLOWMETERS C-02260, C-02369

FLUID FLOW A-05465, A-05718, A-10418,  
A-25220, B-01935, B-06084, B-09789,  
B-22757, B-22822, B-23262

FLUORANTHENES A-01788, A-05005,  
A-10424, F-01798

FLUORESCENCE F-01798, I-14737

FLUORIDES A-09785, D-22812, L-00973,  
L-09677

FLUORINE D-22812

FLUORINE COMPOUNDS A-09785,  
D-22812, L-00973, L-09677

FLY ASH A-00972, A-02009, A-02414,  
A-07561, A-07804, A-08090, A-09158,  
A-09686, A-10433, A-11411, A-11412,  
A-11413, A-11427, A-11431, A-11651,  
A-11934, A-11971, A-14367, A-19052,  
A-20153, A-20646, A-20737, A-20759,  
A-22642, A-25220, A-25862, B-00107,  
B-00183, B-00246, B-00968, B-01437,  
B-01935, B-01936, B-01937, B-01938,  
B-01940, B-01946, B-01947, B-02153,  
B-02389, B-02399, B-02402, B-02738,  
B-04843, B-06096, B-06588, B-08632,  
B-08837, B-09789, B-09823, B-09824,  
B-09826, B-10009, B-10694, B-14364,  
B-14365, B-16730, B-18252, B-19550,  
B-19896, B-19987, B-23008, B-23542,  
C-02260, C-02369, C-15533, K-14366,  
L-00973, L-07522, L-09500, L-09677,  
L-09916, L-19059

FOOD AND FEED OPERATIONS  
A-00972, A-09686, A-23313, A-23314,  
A-24013, B-00246, B-07769, B-09784,  
B-14940, B-25977, L-23765, M-14805

FOODS A-05492

FORMALDEHYDES A-01788, A-11649,  
B-02232, D-22812, F-01798

FRANCE A-06937, A-11428, A-17552,  
B-21435, B-22156, B-24465

FREEZING C-08675

FUEL CHARGING A-02334, A-03155,  
A-03868, A-03870, A-05494, A-05495,  
A-05878, A-06086, A-07561, A-10433,  
A-20153, B-01064, B-01935, B-01936,  
B-01938, B-01944, B-02232, B-06588,  
B-08837, B-12080, B-22757

FUEL EVAPORATION D-02833, L-09500,  
L-09677

FUEL GASES A-00673, A-00972, A-01788,  
A-05005, A-05494, A-05651, A-05815,  
A-05969, A-09785, A-10424, A-10678,  
A-11803, A-24013, B-00107, B-02976,  
B-05852, B-05874, B-09784, B-23008,  
B-26063, C-17468, D-22812, F-01798,  
L-16343, L-18108

FUEL OILS A-00673, A-00943, A-00972,  
A-01788, A-03868, A-05005, A-05160,  
A-05969, A-07963, A-09158, A-09676,  
A-09785, A-10424, A-10678, A-11412,  
A-11413, A-11440, A-11803, A-23313,  
A-23314, A-25056, B-00107, B-04843,



## MUNICIPAL INCINERATORS

B-09784, C-08257, C-23437, D-00149,  
D-22812, J-11114, L-06741, L-09916,  
L-11095, L-18108

**FUELS** A-00673, A-00943, A-00972,  
A-01788, A-03868, A-05005, A-05160,  
A-05465, A-05494, A-05651, A-05815,  
A-05969, A-06086, A-07963, A-09158,  
A-09676, A-09686, A-09785, A-10424,  
A-10433, A-10678, A-11411, A-11412,  
A-11413, A-11440, A-11447, A-11803,  
A-11968, A-17610, A-21991, A-23313,  
A-23314, A-24013, A-25056, A-25549,  
B-00107, B-00975, B-02232, B-02976,  
B-04838, B-04843, B-05852, B-05874,  
B-08178, B-08837, B-09784, B-09823,  
B-09824, B-23008, B-23262, B-26063,  
C-08257, C-17468, C-23437, D-00149,  
D-22812, F-01798, G-23293, J-11114,  
L-00973, L-06741, L-06961, L-08976,  
L-09514, L-09677, L-09916, L-11095,  
L-12511, L-16343, L-18108, M-14805,  
M-24009, N-00164

**FUMES** A-07561, A-09785, A-17604,  
A-22642, B-00107, B-07921, B-08837,  
B-09784, B-09789, B-25511, I-24187,  
L-09677, L-16343, N-01531

**FUNGI** A-09676

**FURNACES** A-00972, A-01788, A-03154,  
A-03155, A-03870, A-05005, A-05160,  
A-05495, A-05497, A-05878, A-09686,  
A-10418, A-10433, A-11440, A-11934,  
A-14367, A-17552, A-22130, A-22540,  
A-24421, A-25056, A-26204, B-00107,  
B-00183, B-00975, B-01935, B-01936,  
B-01943, B-02398, B-09784, B-15201,  
B-15544, B-23262, B-23819, B-25706,  
C-08257, I-14737, J-01294, L-06961,  
L-07202, L-08976, L-09677, L-09916,  
L-22466

## G

**GAS CHROMATOGRAPHY** A-08373,  
A-10424, C-05834, C-08257, C-08675,  
F-01798

**GAS SAMPLING** A-01788, A-05005,  
A-05160, A-09026, B-09784, C-04117,  
C-06095, C-08675, C-15533, C-21663

**GAS TURBINES** B-24954

**GASES** A-01788, A-03155, A-08816,  
A-10424, A-11636, A-22642, A-22860,  
A-22862, B-00975, B-02389, B-02396,  
B-15201, B-16137, F-13618, L-08976

**GASIFICATION (SYNTHESIS)** A-18173

**GASOLINES** A-00673, A-00943, A-00972,  
A-05005, A-09785, F-01798, L-09916,  
N-00164

**GERMANY** A-00712, A-03868, A-05494,  
A-08373, A-08583, A-08816, A-10678,  
A-11411, A-11412, A-11413, A-11427,  
A-11428, A-11429, A-11430, A-11431,  
A-11432, A-11438, A-11439, A-11440,  
A-11447, A-11448, A-11449, A-11450,  
A-11461, A-11636, A-11637, A-11640,  
A-11647, A-11649, A-11651, A-11655,  
A-11657, A-11666, A-11934, A-11939,  
A-11940, A-11961, A-11962, A-11963,  
A-11968, A-11969, A-11971, A-11972,  
A-13112, A-14442, A-18173, A-21882,  
A-24421, A-25549, A-25862, B-00183,  
B-02390, B-02976, B-08727, B-11652,  
B-11658, B-13697, B-14369, B-14736,  
B-16730, B-20773, B-21626, B-23482,  
B-26063, C-08257, H-09275, I-14737,  
I-16420, J-01294, K-22389, L-08976,  
L-12989, L-23126

**GLASS FABRICS** A-05005, A-05492,  
A-08816, A-08850, A-09676, A-09686,  
A-11450, A-18009, B-00107, B-06315,  
B-08632, B-08727, B-09784, B-19987,  
D-22812

**GOVERNMENTS** A-02009, A-05718,  
A-06852, A-12441, A-16514, A-21882,  
A-22862, A-23313, A-23314, B-00107,  
B-00975, B-07973, B-09784, B-14364,  
C-11088, J-03006, L-01948, L-03805,  
L-06961, L-07522, L-08826, L-08976,  
L-09500, L-09514, L-09677, L-09916,  
L-10454, L-10491, L-11095, L-12511,  
L-16343, L-18108, L-19059, L-20133,  
L-23126, L-23765, L-25480, L-25688,  
M-15002, M-24009, N-01531

**GRAIN PROCESSING** B-09784

**GRASSES** A-05492

**GRAVITY SETTLING** A-09686

**GREAT BRITAIN** A-08850, A-10418,  
A-10424, A-11655, L-16343, L-20133

**GROUND LEVEL** A-06370, A-25862

## H

**HALOGEN GASES** A-00712, A-09686,  
A-09785, A-25862, B-02390, D-22812,  
H-09275, I-12055, L-09916

**HALOGENATED HYDROCARBONS**  
A-09785, A-25862, B-04838, L-08826,  
L-09916

**HAZE** A-10678

**HEALTH IMPAIRMENT** B-00975,  
B-07973, D-03454, G-01941, G-23293,  
N-22326

**HEARINGS** L-06741

**HEAT CAPACITY** B-01935

**HEAT OF COMBUSTION** A-07804,  
A-08577, A-09663, A-09671, B-01935,  
B-06588, B-09823, F-14370

**HEAT TRANSFER** A-03870, A-05465,  
A-05492, A-05495, A-05497, A-05651,  
A-08577, A-09663, A-10418, A-23815,  
A-25220, B-01935, B-09824, B-09826,  
B-10009, B-10455, B-14613, B-20773,  
B-24089, C-08675, C-20808, F-13618,  
F-14370, L-03805

**HEIGHT FINDING** L-20133

**HEMEON AUTOMATIC SMOKE  
SAMPLERS** B-00975

**HEXANES** A-00027, C-08675, F-01798

**HEXENES** F-01798

**HI-VOL SAMPLERS** A-05005, A-22540,  
C-24412, D-22812, F-01798

**HOT SOAK** L-09677

**HOURLY** N-00164

**HUMANS** A-09785, A-21991, G-23293

**HUMIDITY** A-09671, B-20773, C-07077,  
F-09284, G-23293

**HYDROCARBONS** A-00027, A-00673,  
A-00972, A-01788, A-05005, A-06086,  
A-07561, A-08373, A-09026, A-09676,  
A-09686, A-09785, A-10424, A-19052,  
A-20276, A-22642, A-23584, A-24013,  
A-25549, A-26204, B-00107, B-00288,  
B-00975, B-02153, B-02232, B-02389,  
B-04838, B-08837, B-09784, B-09826,  
B-10694, B-14967, B-20078, B-20294,  
C-05834, C-08257, C-08675, C-21663,  
C-25696, D-00149, D-02833, D-03454,  
D-22812, F-01798, G-01941, L-00973,  
L-08826, L-08976, L-09677, L-09916,  
N-00164, N-22326

**HYDROCHLORIC ACID** A-08583,  
A-08816, A-11438, A-20646, A-22642,  
A-22862, A-24421, A-25862, A-26204,

B-14369, B-16749, H-09275, I-12055,  
I-19325, L-08976, L-09916

**HYDROFLUORIC ACID** A-08816, D-22812

**HYDROGEN** A-05492, A-25220, B-01947,  
C-05834, D-02395

**HYDROGEN SULFIDE** A-05815, A-09785,  
B-00975, B-02389, B-02390, B-02488,  
B-07921, D-22812, I-12055

**HYDROLYSIS** A-09676

**HYDROXIDES** A-23815

## I

**ILLINOIS** L-00973, L-06961, L-09677,  
L-11095, M-14805

**IMPINGERS** A-06370, A-21951, B-00975,  
B-06315, B-18252, C-01612, D-22812,  
L-10491

**INCINERATION** A-00027, A-00673,  
A-00712, A-00943, A-00972, A-01788,  
A-02009, A-02334, A-02414, A-02773,  
A-03154, A-03155, A-03868, A-03870,  
A-05005, A-05160, A-05465, A-05492,  
A-05493, A-05494, A-05495, A-05497,  
A-05520, A-05651, A-05718, A-05815,  
A-05877, A-05878, A-05969, A-06086,  
A-06370, A-06852, A-06937, A-07206,  
A-07561, A-07659, A-07804, A-07963,  
A-08090, A-08373, A-08577, A-08583,  
A-08816, A-08850, A-09026, A-09158,  
A-09663, A-09671, A-09676, A-09686,  
A-09785, A-10038, A-10418, A-10424,  
A-10433, A-10675, A-10678, A-11411,  
A-11412, A-11413, A-11427, A-11428,  
A-11429, A-11430, A-11431, A-11432,  
A-11438, A-11439, A-11440, A-11447,  
A-11448, A-11449, A-11450, A-11461,  
A-11475, A-11636, A-11637, A-11638,  
A-11640, A-11647, A-11649, A-11651,  
A-11655, A-11657, A-11666, A-11803,  
A-11934, A-11939, A-11940, A-11961,  
A-11962, A-11963, A-11968, A-11969,  
A-11971, A-11972, A-12441, A-13112,  
A-13622, A-14168, A-14367, A-14442,  
A-14923, A-14972, A-16254, A-16514,  
A-16710, A-16869, A-17243, A-17462,  
A-17552, A-17604, A-17610, A-18009,  
A-18173, A-19052, A-19547, A-20153,  
A-20276, A-20517, A-20583, A-20646,  
A-20737, A-20759, A-20906, A-21492,  
A-21882, A-21952, A-21991, A-22130,  
A-22540, A-22642, A-22860, A-22862,  
A-22873, A-23025, A-23313, A-23314,  
A-23584, A-23815, A-24013, A-24241,  
A-24421, A-24582, A-24767, A-25056,  
A-25220, A-25549, A-25862, A-26204,  
B-00107, B-00183, B-00246, B-00288,  
B-00582, B-00968, B-00975, B-01064,  
B-01437, B-01935, B-01936, B-01937,  
B-01938, B-01939, B-01940, B-01942,  
B-01943, B-01944, B-01945, B-01946,  
B-01947, B-02027, B-02153, B-02186,  
B-02232, B-02387, B-02388, B-02389,  
B-02390, B-02394, B-02396, B-02397,  
B-02398, B-02399, B-02400, B-02401,  
B-02402, B-02488, B-02738, B-02741,  
B-02976, B-03229, B-04838, B-04843,  
B-05498, B-05569, B-05570, B-05852,  
B-05874, B-06084, B-06096, B-06315,  
B-06588, B-07426, B-07769, B-07921,  
B-07973, B-08178, B-08632, B-08727,  
B-08837, B-09784, B-09789, B-09823,  
B-09824, B-09826, B-10009, B-10455,  
B-10694, B-11652, B-11658, B-11792,  
B-12080, B-12651, B-12655, B-12664,

# SUBJECT INDEX

89

- B-13133, B-13363, B-13697, B-14061,  
B-14364, B-14365, B-14369, B-14522,  
B-14524, B-14612, B-14613, B-14736,  
B-14940, B-14967, B-15201, B-15396,  
B-15544, B-16137, B-16536, B-16730,  
B-16749, B-16751, B-17275, B-17403,  
B-18252, B-19236, B-19550, B-19597,  
B-19896, B-19941, B-19987, B-20078,  
B-20294, B-20728, B-20730, B-20773,  
B-21058, B-21435, B-21626, B-22156,  
B-22296, B-22757, B-22808, B-22821,  
B-22822, B-23008, B-23262, B-23482,  
B-23542, B-23819, B-23836, B-23856,  
B-24089, B-24465, B-24954, B-25511,  
B-25570, B-25706, B-25977, B-26063,  
C-01612, C-02260, C-02369, C-02391,  
C-04117, C-05834, C-06095, C-07077,  
C-08257, C-08675, C-11088, C-14368,  
C-15533, C-17352, C-17468, C-19580,  
C-20808, C-21663, C-23437, C-24412,  
C-25696, D-00149, D-02395, D-02833,  
D-03454, D-22812, F-01798, F-09284,  
F-13618, F-14370, G-01941, G-23167,  
G-23293, H-09275, I-12055, I-14737,  
I-16420, I-19325, I-24187, J-01294,  
J-02392, J-03006, J-11114, J-11857,  
K-05197, K-07595, K-12118, K-14366,  
K-17201, K-22375, K-22389, L-00973,  
L-01948, L-02393, L-03805, L-05496,  
L-06741, L-06961, L-07202, L-07522,  
L-07879, L-08826, L-08976, L-09500,  
L-09514, L-09677, L-09916, L-10454,  
L-10491, L-10567, L-11095, L-12511,  
L-12989, L-16343, L-18108, L-19059,  
L-20133, L-20861, L-22466, L-23126,  
L-23765, L-25480, L-25688, M-06085,  
M-14805, M-15002, M-24009, N-00164,  
N-01531, N-22326
- INDIANA L-00973, L-09677, L-25480
- INDUSTRIAL AREAS A-02414, A-05815,  
A-08850, A-22540, B-09823, L-07522,  
L-08976, L-09514, L-09677, L-10567
- INDUSTRIAL EMISSION SOURCES  
A-00027, A-00673, A-00712, A-00943,  
A-00972, A-01788, A-02009, A-02334,  
A-02414, A-02773, A-03154, A-03155,  
A-03868, A-03870, A-05005, A-05160,  
A-05465, A-05492, A-05493, A-05494,  
A-05495, A-05497, A-05520, A-05651,  
A-05718, A-05815, A-05877, A-05878,  
A-05969, A-06086, A-06370, A-06852,  
A-06937, A-07206, A-07561, A-07659,  
A-07804, A-07963, A-08090, A-08373,  
A-08577, A-08583, A-08816, A-08850,  
A-09026, A-09158, A-09663, A-09671,  
A-09676, A-09686, A-09785, A-10038,  
A-10418, A-10424, A-10433, A-10675,  
A-10678, A-11411, A-11412, A-11413,  
A-11427, A-11428, A-11429, A-11430,  
A-11431, A-11432, A-11438, A-11439,  
A-11440, A-11447, A-11448, A-11449,  
A-11450, A-11461, A-11475, A-11636,  
A-11637, A-11638, A-11640, A-11647,  
A-11649, A-11651, A-11655, A-11657,  
A-11666, A-11803, A-11934, A-11939,  
A-11940, A-11961, A-11962, A-11963,  
A-11968, A-11969, A-11971, A-11972,  
A-12441, A-13112, A-13622, A-14168,  
A-14367, A-14442, A-14923, A-14972,  
A-16254, A-16514, A-16710, A-16869,  
A-17243, A-17462, A-17552, A-17604,  
A-17610, A-18009, A-18173, A-19052,  
A-19547, A-20153, A-20276, A-20517,  
A-20585, A-20646, A-20737, A-20759,  
A-20906, A-21492, A-21882, A-21952,  
A-21991, A-22130, A-22540, A-22642,
- A-22860, A-22862, A-22873, A-23025,  
A-23313, A-23314, A-23584, A-23815,  
A-24013, A-24241, A-24421, A-24582,  
A-24767, A-25056, A-25220, A-25549,  
A-25862, A-26204, B-00107, B-00183,  
B-00246, B-00288, B-00582, B-00968,  
B-00975, B-01064, B-01437, B-01935,  
B-01936, B-01937, B-01938, B-01939,  
B-01940, B-01942, B-01943, B-01944,  
B-01945, B-01946, B-01947, B-02027,  
B-02153, B-02186, B-02232, B-02387,  
B-02388, B-02389, B-02390, B-02394,  
B-02396, B-02397, B-02398, B-02399,  
B-02400, B-02401, B-02402, B-02488,  
B-02738, B-02741, B-02976, B-03229,  
B-04838, B-04843, B-05498, B-05569,  
B-05570, B-05852, B-05874, B-06084,  
B-06096, B-06315, B-06588, B-07426,  
B-07769, B-07921, B-07973, B-08178,  
B-08632, B-08727, B-08837, B-09784,  
B-09789, B-09823, B-09824, B-09826,  
B-10009, B-10455, B-10694, B-11652,  
B-11658, B-11792, B-12080, B-12651,  
B-12655, B-12664, B-13133, B-13363,  
B-13697, B-14061, B-14364, B-14365,  
B-14369, B-14522, B-14524, B-14612,  
B-14613, B-14736, B-14940, B-14967,  
B-15201, B-15396, B-15544, B-16137,  
B-16536, B-16730, B-16749, B-16751,  
B-17275, B-17403, B-18252, B-19236,  
B-19550, B-19597, B-19896, B-19941,  
B-19987, B-20078, B-20294, B-20728,  
B-20730, B-20773, B-21058, B-21435,  
B-21626, B-22156, B-22296, B-22757,  
B-22808, B-22821, B-22822, B-23008,  
B-23262, B-23482, B-23542, B-23819,  
B-23836, B-23856, B-24089, B-24465,  
B-24954, B-25511, B-25570, B-25706,  
B-25977, B-26063, C-01612, C-02260,  
C-02369, C-02391, C-04117, C-05834,  
C-06095, C-07077, C-08257, C-08675,  
C-11088, C-14368, C-15533, C-17352,  
C-17468, C-19580, C-20808, C-21663,  
C-23437, C-24412, C-25696, D-00149,  
D-02395, D-02833, D-03454, D-22812,  
F-01798, F-09284, F-13618, F-14370,  
G-01941, G-23167, G-23293, H-09275,  
I-12055, I-14737, I-16420, I-19325,  
I-24187, J-01294, J-02392, J-03006,  
J-11114, J-11857, K-05197, K-07595,  
K-12118, K-14366, K-17201, K-22375,  
K-22389, L-00973, L-01948, L-02393,  
L-03805, L-05496, L-06741, L-06961,  
L-07202, L-07522, L-07879, L-08826,  
L-08976, L-09500, L-09514, L-09677,  
L-09916, L-10454, L-10491, L-10567,  
L-11095, L-12511, L-12989, L-16343,  
L-18108, L-19059, L-20133, L-20861,  
L-22466, L-23126, L-23765, L-25480,  
L-25688, M-06085, M-14805, M-15002,  
M-24009, N-00164, N-01531, N-22326
- INERTIAL SEPARATION B-19550
- INFRARED SPECTROMETRY A-00027,  
A-08373, A-21991, B-02232
- INORGANIC ACIDS A-08583, A-08816,  
A-09676, A-09686, A-09785, A-11438,  
A-20646, A-22642, A-22862, A-24421,  
A-25549, A-25862, A-26204, B-00975,  
B-09784, B-09789, B-14369, B-16749,  
D-22812, G-01941, H-09275, I-12055,  
I-19325, L-08976, L-09916
- INSPECTION A-10675, B-21626, L-09916
- INSPECTORS B-00975
- INSTRUCTORS B-00975
- INSTRUMENTATION A-03155, A-05495,  
A-10418, A-20906, B-00975, B-01943,
- B-01946, B-09789, B-12651, B-12655,  
C-02260, C-02369, C-02391, C-08675,  
L-02393
- INTERNAL COMBUSTION ENGINES  
A-00673, A-03154, A-05005, A-05169,  
A-09686, A-10424, A-11803, A-20585,  
A-22540, A-24013, A-25549, B-08837,  
B-15544, B-20294, D-00149, D-02833,  
G-23167, L-08976, L-09677, L-09916,  
N-00164
- INVERSION A-09785, A-10424, A-10678,  
A-14972, B-00975, L-08976, M-24009
- IODIMETRIC METHODS D-22812
- IRON A-00972, A-05005, A-09686, A-16869,  
B-08837, B-09784, B-09789, B-09823,  
B-09824, B-09826, I-24187, L-00973,  
L-22466
- IRON COMPOUNDS A-05492, A-09785,  
B-01947, B-16749, I-12055
- IRON OXIDES A-05492, I-12055
- ISOTOPES C-02369
- ITALY A-07206, A-08577
- J
- JAPAN A-14168, A-17243, A-17462,  
A-20646, A-22130, A-22540, A-24241,  
A-25056, B-14364, B-14940, B-15396,  
B-16137, B-16536, B-17403, B-21058,  
B-23262, C-17468, I-19325, K-17201,  
L-07202
- JET AIRCRAFT N-00164
- K
- KENTUCKY L-09677, L-25480
- KEROSENE A-00943
- KETONES A-09026, A-09676, A-09785,  
C-21663, L-08826
- KIDNEYS G-23167
- KILNS A-00972, A-03154, A-03155,  
A-05160, A-25549, A-26204, B-20728,  
B-26063, L-06961, L-09677, L-22466
- KRAFT PULPING A-09686, B-07769,  
B-09789, B-14940, B-25977
- L
- LABORATORY ANIMALS G-23167
- LABORATORY FACILITIES A-23584,  
B-20078, C-01612
- LANDFILLS A-02414, A-08850, A-09676,  
A-11651, A-18009, A-19052, A-23313,  
A-23314, B-02741, B-04843, B-07973,  
B-10694, B-11792, L-07522, L-09916,  
L-10454, L-11095, N-01531
- LAUNDRIES L-19059, L-23765
- LEAD A-09686, B-00107
- LEAD COMPOUNDS A-09785, G-23167
- LEATHER A-05492, A-08850
- LEAVES H-09275
- LEGAL ASPECTS A-05718, A-07804,  
A-10675, A-12441, A-13112, A-23313,  
A-23314, B-00107, B-00288, B-00975,  
B-01938, B-02400, B-08632, B-09784,  
B-14522, B-21626, D-03454, G-23293,  
J-11857, K-12118, L-00973, L-03805,  
L-06741, L-06961, L-07202, L-08826,  
L-08976, L-09500, L-09514, L-09677,  
L-09916, L-10454, L-10491, L-10567,  
L-11095, L-12511, L-12989, L-16343,  
L-18108, L-19059, L-20133, L-20861,  
L-22466, L-23126, L-23765, L-25480,  
L-25688, M-24009, N-01531



## MUNICIPAL INCINERATORS

LEGISLATION A-12441, B-00288, B-00975,  
B-08632, D-03454, L-00973, L-07202,  
L-08826, L-09677, L-09916, L-10454,  
L-11095, L-16343, L-20133, L-20861,  
L-22466, L-23765, L-25480, L-25688,  
M-24009  
LIGHT RADIATION G-23293  
LIME L-22466  
LIQUIDS A-03155, A-05465, A-05492,  
A-05497, A-05969, A-06086, A-09676,  
A-14923, A-20276, A-23815, B-01935,  
B-01947, B-02389, B-02396, B-05570,  
B-06096, B-19896, B-20773, C-20808,  
F-13618  
LOCAL GOVERNMENTS A-02009,  
B-00975, B-07973, L-09677, L-12511,  
L-18108  
LOS ANGELES A-05160, A-06852,  
A-09785, A-11638, A-12441, B-00107,  
B-00288, B-00975, B-09784, L-00973,  
L-08826, L-09677  
LOUISIANA D-00149  
LUBRICANTS A-08850  
LUNG CANCER A-20585

## M

MAGNESIUM B-00107  
MAGNESIUM COMPOUNDS A-09785,  
B-01947  
MAINTENANCE A-02334, A-09676,  
B-01940, B-02976, B-05569, B-06315,  
B-07769, B-14365, B-14369, B-21626,  
I-24187, K-07595, L-09916  
MANGANESE COMPOUNDS A-09785  
MAPPING A-10678  
MARYLAND A-23313, A-23314  
MASS SPECTROMETRY D-03454  
MATERIALS DETERIORATION A-03868,  
A-08816, A-17610, B-00975, B-14369,  
B-15201, I-12055, I-14737, I-16420,  
I-19325, I-24187, K-14366, N-00164  
MATHEMATICAL ANALYSES A-24767,  
B-01935, C-02369, C-07077, C-14368,  
F-09284, F-14370, K-22375  
MAXIMUM ALLOWABLE  
CONCENTRATION A-11461,  
A-11638, A-11649, A-25549, B-00288,  
B-00975, B-02153, B-02389, B-02390,  
L-00973, L-03805, L-07202, L-08826,  
L-09677, L-23126  
MEASUREMENT METHODS A-05005,  
A-05718, A-08373, A-10418, A-11649,  
A-11963, A-21991, B-00975, B-01947,  
B-02232, B-02388, B-08727, B-09784,  
B-10009, B-12651, B-12655, B-14967,  
B-23008, C-02260, C-02369, C-02391,  
C-04117, C-06095, C-07077, C-08257,  
C-11088, C-15533, C-17352, C-17468,  
C-21663, C-23437, C-24412, F-01798,  
L-09500  
MEETINGS L-08826  
MEMBRANE FILTERS A-06370, B-06315,  
D-22812  
MERCAPTANS B-02488, B-04838  
METAL COMPOUNDS A-05492, A-09676,  
A-09686, A-09785, A-20585, B-01947,  
B-04838, B-09784, B-16749, C-17352,  
G-23167, I-12055, N-22326  
METAL FABRICATING AND FINISHING  
A-03154, A-07659, A-20585, B-00975,  
B-08837, B-09784, B-26063, C-17468,  
M-14805  
METAL POISONING G-23167

METALS A-00972, A-05005, A-05492,  
A-08850, A-09676, A-09686, A-11450,  
A-16869, A-18009, B-00107, B-08837,  
B-09784, B-09789, B-09823, B-09824,  
B-09826, I-24187, L-00973, L-11095,  
L-22466  
METEOROLOGY A-09671, A-09785,  
A-10424, A-10675, A-10678, A-14972,  
A-23313, B-00975, B-02401, B-07973,  
B-20773, C-07077, C-24412, D-00149,  
D-02833, D-03454, F-09284, G-23293,  
L-08976, L-09514, L-09916, L-25480,  
L-25688, M-24009, N-22326  
METHANES A-09676, B-04838, C-08675,  
F-01798  
MICE G-23167  
MICHIGAN B-05874, L-00973, L-09677,  
L-22466  
MICROORGANISMS A-09676, A-20517,  
D-22812  
MICROSCOPY C-07077  
MINERAL PROCESSING A-00943,  
A-00972, A-22873, A-24013, B-00107,  
B-00975, B-14940, B-26063, C-21663,  
L-09677, L-22466, L-23765, N-00164  
MINERAL PRODUCTS A-05492, A-09785,  
A-22873, B-00975, B-09784, B-09789,  
B-24465  
MINING N-00164  
MISSOURI A-03870, B-00968, B-01064,  
B-01935, B-01936, B-01937, B-01944,  
B-02232, B-02394, B-02397, L-00973,  
L-09677  
MISTS B-09789  
MOBILE B-09824  
MOLYBDENUM I-24187  
MOLYBDENUM COMPOUNDS A-09785  
MONITORING A-05005, A-10418, B-02232,  
B-02388, B-08727, B-10009, C-02260,  
C-02369, C-08257, C-15533, C-17468,  
C-24412  
MONTHLY A-10424  
MORTALITY G-23167, N-22326  
MULTIPLE CHAMBER INCINERATORS  
A-00712, A-02334, A-02414, A-03155,  
A-05005, A-05160, A-05520, A-05718,  
A-06086, A-07804, A-08373, A-10675,  
A-10678, A-11428, A-12441, A-14367,  
A-16514, A-16710, A-20153, A-20737,  
A-20759, A-24241, A-24582, A-24767,  
B-00183, B-00246, B-01064, B-01944,  
B-02186, B-02232, B-06084, B-07426,  
B-09784, B-09823, B-09824, B-09826,  
B-10694, B-12664, B-14061, B-16751,  
B-17275, B-20730, B-22156, B-23008,  
B-23836, B-24089, B-26063, C-08675,  
J-11857, K-07595, L-07522, L-10491,  
M-06085

## N

NAPHTHACENES F-01798  
NAPHTHALENES F-01798  
NASHVILLE L-19059  
NATURAL GAS A-00972, A-01788,  
A-05494, A-05815, A-09785, A-10424,  
A-10678, A-11803, A-24013, B-00107,  
B-05874, D-22812, F-01798, L-18108  
NERVOUS SYSTEM G-23167, G-23293  
NEUTRON ACTIVATION ANALYSIS  
A-17604  
NEW JERSEY D-03454, L-00973, L-09677,  
L-09916, L-11095  
NEW ORLEANS D-00149

NEW YORK CITY A-11638, A-11803,  
A-12441, A-14923, D-03454, J-01294,  
J-11114, K-05197, K-07595, L-00973,  
L-09514, L-09677, L-11095, L-18108,  
M-15002  
NEW YORK STATE A-00673, A-05492,  
A-05495, A-11638, A-11803, A-12441,  
A-14923, B-05569, B-07426, D-02833,  
D-03454, J-01294, J-11114, K-05197,  
K-07595, L-00973, L-09514, L-09677,  
L-11095, L-18108, M-15002, M-24009  
NICKEL I-24187  
NICKEL COMPOUNDS A-09785, A-20585,  
G-23167  
NITRIC ACID A-09686, I-19325  
NITRIC OXIDE (NO) A-00027, A-05815,  
A-09026, A-09785, B-00107, B-00975,  
D-00149, N-00164  
NITROGEN A-05492, A-05718, A-09676,  
A-14923, B-01935, B-01947, B-07426,  
D-02395  
NITROGEN DIOXIDE (NO<sub>2</sub>) A-00027,  
A-00673, A-05815, A-06086, A-07561,  
A-09026, A-09686, A-09785, A-11803,  
B-00107, B-00975, D-00149, D-22812,  
N-00164, N-22326  
NITROGEN OXIDES A-00027, A-00673,  
A-00972, A-01788, A-03154, A-05160,  
A-05815, A-06086, A-07561, A-09026,  
A-09686, A-09785, A-11803, A-19052,  
A-20646, A-21952, A-22540, A-22862,  
A-24013, A-25220, B-00107, B-00288,  
B-00975, B-02153, B-02232, B-02390,  
B-02396, B-09784, B-09826, B-10694,  
B-14967, B-23008, C-21663, D-00149,  
D-03454, D-22812, G-01941, G-23293,  
I-19325, L-08976, L-09677, L-09916,  
N-00164, N-22326  
NON-INDUSTRIAL EMISSION SOURCES  
A-00673, A-00712, A-00943, A-00972,  
A-01788, A-02009, A-02334, A-02414,  
A-02773, A-03154, A-03155, A-03868,  
A-03870, A-05005, A-05465, A-05492,  
A-05493, A-05494, A-05495, A-05497,  
A-05651, A-05815, A-05877, A-05878,  
A-05969, A-06086, A-06852, A-06937,  
A-07206, A-07561, A-07659, A-07804,  
A-08090, A-08373, A-08577, A-08583,  
A-08816, A-08850, A-09026, A-09158,  
A-09663, A-09671, A-09676, A-09686,  
A-09785, A-10038, A-10418, A-10433,  
A-10675, A-10678, A-11411, A-11412,  
A-11413, A-11427, A-11428, A-11429,  
A-11430, A-11431, A-11432, A-11438,  
A-11439, A-11440, A-11447, A-11448,  
A-11449, A-11450, A-11461, A-11636,  
A-11637, A-11638, A-11640, A-11647,  
A-11649, A-11651, A-11655, A-11657,  
A-11666, A-11934, A-11939, A-11940,  
A-11961, A-11963, A-11968, A-11971,  
A-11972, A-13622, A-14367, A-14442,  
A-14923, A-17243, A-17462, A-17552,  
A-17604, A-18009, A-18173, A-19052,  
A-21492, A-22860, A-23025, A-23313,  
A-23314, A-24013, A-25056, A-25220,  
A-25549, A-25862, A-26204, B-00288,  
B-00582, B-00975, B-01437, B-01935,  
B-01937, B-01938, B-01943, B-01944,  
B-01945, B-01946, B-01947, B-02027,  
B-02153, B-02232, B-02388, B-02389,  
B-02390, B-02394, B-02397, B-02398,  
B-02399, B-02400, B-02401, B-02738,  
B-02741, B-03229, B-04843, B-05498,  
B-05569, B-05570, B-05852, B-05874,  
B-06084, B-06096, B-06315, B-06588,  
B-07769, B-07973, B-08632, B-08727,



# SUBJECT INDEX

91

B-09784, B-09823, B-09826, B-10009,  
B-10694, B-11652, B-11658, B-11792,  
B-12080, B-13697, B-14061, B-14364,  
B-14369, B-14522, B-14524, B-14612,  
B-14613, B-14940, B-14967, B-16536,  
B-16730, B-16749, B-16751, B-17275,  
B-17403, B-19597, B-19941, B-20730,  
B-21626, B-22808, B-23008, B-23836,  
B-24089, B-24954, B-25977, C-02391,  
C-07077, C-11088, D-00149, D-02395,  
D-02833, D-03454, F-01798, F-09284,  
G-01941, H-09275, I-12055, J-01294,  
J-02392, J-03006, J-11857, K-07595,  
K-14366, L-00973, L-01948, L-02393,  
L-03805, L-05496, L-07522, L-07879,  
L-08976, L-09500, L-09514, L-09677,  
L-09916, L-10454, L-10491, L-10567,  
L-11095, L-16343, L-18108, L-19059,  
L-20133, L-23126, L-23765, L-25480,  
L-25688, M-14805, N-00164, N-01531  
NON-URBAN AREAS A-08850, A-22540,  
D-00149, L-11095  
NUCLEAR POWER PLANTS L-18108

## O

OCEANS B-07973  
ODOR COUNTERACTION A-11651,  
A-20276, A-25056, B-07921, B-12651,  
B-12655, B-14940, B-23008, B-23836,  
B-25977, I-24187  
ODORIMETRY C-04117  
ODORS A-02334, A-05815, A-07561,  
A-08373, A-09785, A-10418, A-11969,  
A-14972, A-17462, A-18009, A-20276,  
A-21882, A-22860, A-23313, A-23314,  
B-00183, B-00246, B-00975, B-02488,  
B-02976, B-04838, B-05852, B-05874,  
B-06096, B-06588, B-07921, B-09784,  
B-09823, B-09824, B-10009, B-13697,  
B-14364, B-14967, B-17403, B-23008,  
B-23836, B-25977, C-04117, I-19325,  
L-00973, L-09677, L-09916, L-10567,  
L-12511, L-19059  
OHIO C-01612, C-07077, D-00149, L-00973,  
L-09677, L-25480, L-25688  
OIL BURNERS A-01788, A-05160,  
A-10418, B-25706, C-08257, L-09916  
OLEFINS A-09785, A-10424, C-08675,  
F-01798, L-08826  
OPEN BURNING A-00673, A-00712,  
A-00972, A-01788, A-05005, A-09686,  
A-23313, A-23314, A-24013, A-25549,  
B-09784, B-11792, D-03454, L-07522,  
L-09500, L-09916, L-11095, L-16343,  
L-19059, L-25480, L-25688, N-00164  
OPEN HEARTH FURNACES A-00972,  
A-05160, A-09686, A-14367, B-00107,  
L-09677  
OPERATING CRITERIA A-02334, A-12441,  
A-22862, B-02387, B-02388, B-02389,  
B-02390, B-02394, B-02396, B-02398,  
B-02399, B-02400, B-02401, B-14524,  
C-02391, D-02395, J-02392, K-05197,  
K-12118, L-01948, L-02393, L-09677  
OPERATING VARIABLES A-03868,  
A-05465, A-09026, A-11972, A-12441,  
A-16254, A-16514, A-17462, A-20517,  
A-20646, A-21492, A-21952, A-22860,  
A-22862, A-24241, A-24767, A-25220,  
B-02396, B-05569, B-05570, B-06096,  
B-06315, B-07769, B-15201, B-17403,  
B-19896, B-21435, B-21626, B-22808,  
B-23482, B-23856, I-19325, J-02392,  
K-05197, K-07595  
OPINION SURVEYS M-06085

OREGON L-09677  
ORGANIC ACIDS A-00673, A-00972,  
A-05815, A-07561, A-09026, A-09676,  
A-09686, A-09785, A-11649, A-20646,  
B-00975, B-09826, B-10694, B-14967,  
G-01941, I-19323  
ORGANIC NITROGEN COMPOUNDS  
B-02389  
ORGANIC PHOSPHORUS COMPOUNDS  
B-00975  
ORGANIC SULFUR COMPOUNDS  
B-00975, B-02488, B-04838  
ORGANIC WASTES A-08577, A-09676,  
B-05570, B-11792, B-14364, B-25977  
ORSAT ANALYSIS A-05718, B-01947,  
C-04117  
OVERFIRE AIR A-05465, A-05969,  
A-22642, A-22862, A-24767, B-02232,  
B-05498, B-06588, B-09823, B-09826,  
B-10009, B-22757, B-22822  
OXIDANT PRECURSORS B-00975  
OXIDANTS A-00673, A-00943, A-09785,  
B-00975, G-23293, N-00164  
OXIDATION A-07659, A-08850, A-11475,  
A-23584, A-26204, B-04838, B-07921,  
I-12055  
OXIDES A-00027, A-00673, A-00943,  
A-00972, A-01788, A-02009, A-03154,  
A-05160, A-05465, A-05492, A-05718,  
A-05815, A-05969, A-06086, A-07561,  
A-07963, A-08373, A-08583, A-09026,  
A-09676, A-09686, A-09785, A-10418,  
A-10678, A-11438, A-11649, A-11803,  
A-14923, A-19052, A-20276, A-20646,  
A-21952, A-22540, A-22642, A-22862,  
A-24013, A-25220, B-00107, B-00288,  
B-00975, B-01935, B-01947, B-02153,  
B-02232, B-02389, B-02390, B-02396,  
B-04838, B-06084, B-07426, B-07921,  
B-08727, B-08837, B-09784, B-09826,  
B-10694, B-14369, B-14522, B-14967,  
B-16730, B-16749, B-18252, B-20294,  
B-23008, C-02260, C-04117, C-06095,  
C-17468, C-21663, C-25696, D-00149,  
D-02833, D-03454, D-22812, G-01941,  
G-23293, I-12055, I-19325, J-11114,  
L-00973, L-07202, L-08976, L-09500,  
L-09514, L-09677, L-09916, L-11095,  
L-12511, L-18108, L-19059, L-20861,  
L-25480, L-25688, M-14805, N-00164,  
N-22326  
OXYGEN A-00027, A-01788, A-05465,  
A-05492, A-05718, A-09026, A-11427,  
A-11475, A-14923, B-01935, B-01947,  
B-02232, B-07426, B-14522, B-16730,  
D-02395  
OXYGEN LANCING A-09686  
OZONE A-09785, A-10424, B-00975,  
D-03454, D-22812, G-23293

## P

PAINT MANUFACTURING A-09686,  
L-08826  
PAINTS D-03454  
PAPER CHROMATOGRAPHY A-05492,  
A-06086, A-08850, A-09676, A-11475,  
A-18009, B-02027, B-02232, B-05570,  
B-09823, B-09826, B-22156, F-01798,  
F-09284  
PAPER MANUFACTURING A-00972,  
A-09686, A-17243, B-09789, B-25570,  
J-11857  
PARIS A-06937, A-11428  
PARTICLE COUNTERS C-21663

PARTICLE SIZE A-05718, A-05969,  
A-06370, A-22540, A-25220, B-00288,  
B-00968, B-01937, B-02153, B-02402,  
B-08632, B-09789, B-23262, C-01612,  
C-07077, L-09500  
PARTICULATE CLASSIFIERS A-05718,  
A-05969, A-06370, A-22540, A-25220,  
B-00288, B-00968, B-01937, B-02153,  
B-02402, B-08632, B-09789, B-23262,  
C-01612, C-07077, C-17352, L-09500  
PARTICULATE SAMPLING A-01788,  
A-05718, A-09026, B-02232, B-06096,  
B-07426, B-21626, C-01612, C-04117,  
C-06095, C-07077, C-11088, C-14368,  
C-19580, L-10491  
PARTICULATES A-00027, A-00673,  
A-00712, A-00972, A-01788, A-02009,  
A-02334, A-02414, A-02773, A-03155,  
A-05005, A-05465, A-05492, A-05718,  
A-05815, A-05969, A-06086, A-07206,  
A-07561, A-07804, A-08090, A-08373,  
A-08583, A-09026, A-09158, A-09671,  
A-09686, A-09785, A-10418, A-10424,  
A-10433, A-10678, A-11411, A-11412,  
A-11413, A-11427, A-11429, A-11431,  
A-11432, A-11461, A-11651, A-11803,  
A-11934, A-11971, A-13112, A-13622,  
A-14367, A-14923, A-14972, A-17462,  
A-17552, A-17604, A-19052, A-20153,  
A-20276, A-20585, A-20646, A-20737,  
A-20759, A-21882, A-21952, A-22130,  
A-22540, A-22642, A-22860, A-22862,  
A-23313, A-23314, A-24013, A-24421,  
A-24582, A-25056, A-25220, A-25549,  
A-25862, A-26204, B-00107, B-00183,  
B-00246, B-00288, B-00968, B-00975,  
B-01437, B-01935, B-01936, B-01937,  
B-01938, B-01939, B-01940, B-01944,  
B-01946, B-01947, B-02027, B-02153,  
B-02232, B-02387, B-02389, B-02390,  
B-02397, B-02398, B-02399, B-02400,  
B-02402, B-02738, B-02976, B-04838,  
B-04843, B-05498, B-05852, B-05874,  
B-06096, B-06315, B-06588, B-07426,  
B-07769, B-07921, B-08632, B-08727,  
B-08837, B-09784, B-09789, B-09823,  
B-09824, B-09826, B-10009, B-10455,  
B-10694, B-11658, B-11792, B-13363,  
B-13697, B-14061, B-14364, B-14365,  
B-14369, B-14522, B-14736, B-14967,  
B-15201, B-16137, B-16730, B-17403,  
B-18252, B-19550, B-19597, B-19896,  
B-19987, B-20294, B-20730, B-21058,  
B-21435, B-21626, B-22156, B-22296,  
B-22757, B-22821, B-22822, B-23008,  
B-23262, B-23482, B-23542, B-23836,  
B-23856, B-24954, B-25511, B-25570,  
B-25706, B-26063, C-01612, C-02260,  
C-02369, C-02391, C-04117, C-07077,  
C-08257, C-11088, C-15533, C-17352,  
C-17468, C-19580, C-20808, C-21663,  
C-23437, C-24412, D-02833, D-03454,  
D-22812, F-01798, G-01941, G-23293,  
H-09275, I-24187, J-01294, J-11114,  
K-07595, K-14366, K-17201, K-22389,  
L-00973, L-02393, L-03805, L-06741,  
L-06961, L-07202, L-07522, L-08976,  
L-09500, L-09514, L-09677, L-09916,  
L-10491, L-10567, L-11095, L-12511,  
L-12989, L-16343, L-18108, L-19059,  
L-20133, L-20861, L-22466, L-25480,  
L-25688, N-00164, N-01531, N-22326  
PENNSYLVANIA L-00973, L-07522,  
L-09677, L-10567, L-11095  
PENTANES C-08675, F-01798  
PENTENES C-08675

## MUNICIPAL INCINERATORS

PERMITS B-09784, L-06961, L-10567, L-22466  
 PERSONNEL A-13622, B-00975, B-08837, L-09916, L-20861  
 PERYLENES A-01788, A-10424, F-01798  
 PESTICIDES B-02488, B-09784  
 PETROLEUM DISTRIBUTION B-09784, L-09500, N-00164  
 PETROLEUM PRODUCTION A-00972, A-22540, B-00107, C-17468, C-21663  
 PETROLEUM REFINING A-03154, A-05005, A-07963, A-09686, A-09785, A-17604, A-22540, B-00107, B-00975, B-07769, B-09784, B-09789, B-14940, C-17468, C-21663, D-03454, L-11095  
 PH B-00968, N-22326  
 PHENANTHRENES A-01788, F-01798  
 PHENOLS A-07561, A-09676, G-01941  
 PHILADELPHIA L-07522, L-10567, L-11095  
 PHOSPHORIC ACID A-09686, B-09784, B-09789  
 PHOSPHORUS COMPOUNDS A-00972, B-02488  
 PHOTOCHEMICAL REACTIONS A-09785, A-21991, C-24412, D-03454  
 PHOTOGRAPHIC METHODS D-03454  
 PHOTOMETRIC METHODS C-04117, C-21663  
 PHYSICAL STATES A-00673, A-01788, A-03155, A-05465, A-05492, A-05493, A-05497, A-05969, A-06086, A-08816, A-09663, A-09676, A-10424, A-11428, A-11636, A-14923, A-20276, A-22642, A-22860, A-22862, A-23025, A-23815, B-00975, B-01935, B-01947, B-02389, B-02396, B-05570, B-06096, B-14613, B-15201, B-16137, B-19896, B-20773, B-21058, B-25706, C-20808, C-23437, F-13618, L-08976  
 PILOT PLANTS A-05969, A-09026, A-11412, A-21952, A-25056, B-23856  
 PLAINS B-07973  
 PLANNING AND ZONING G-23293, J-11857, L-00973, L-08976, L-09514, L-09677, L-23126, L-23765, L-25480, L-25688, M-24009, N-01531  
 PLANS AND PROGRAMS A-05718, A-07963, A-09785, A-23313, A-23314, B-00975, B-01437, B-01938, B-01945, B-07973, B-10694, B-12664, B-14364, C-04117, C-07077, D-00149, D-02833, D-03454, L-02393, L-06961, L-07522, L-08976, L-09677, L-09916, L-10454, L-10491, L-10567, L-11095, L-19059, L-23765, L-25480, L-25688, M-15002, N-00164  
 PLANT DAMAGE A-24421, B-00975, H-09275  
 PLANT INDICATORS A-17604  
 PLANTS (BOTANY) A-05492, A-06086, A-08850, A-09785, B-00975, H-09275, N-00164  
 PLASTICS A-05492, A-08816, A-08850, A-11450, A-18009, A-24241, A-25862, B-05570, B-09826, D-00149, I-16420  
 PLATING A-09785, B-09784  
 PLUME BEHAVIOR A-14972, B-00975, B-04838  
 PNEUMONIA A-17604  
 POINT SOURCES L-25480, L-25688  
 POLLUTION PRECURSORS B-00975  
 POLYNUCLEAR COMPOUNDS A-00972, A-01788, A-05005, A-10424, A-25549, B-10694, F-01798, G-01941, L-08976  
 POTASSIUM COMPOUNDS B-01947, B-16749

POTATOES A-06086  
 POTENTIOMETRIC METHODS C-25696  
 POWER CYCLES B-02397, N-00164  
 POWER SOURCES A-00673, A-03154, A-05005, A-05969, A-09686, A-10424, A-11803, A-20585, A-22540, A-24013, A-25549, B-08837, B-15544, B-20294, B-24954, D-00149, D-02833, G-23167, L-08976, L-09677, L-09916, N-00164  
 PRECIPITATION M-24009, N-22326  
 PRESSURE A-10418, B-00968, B-06084, B-19896, B-22822, C-08257, L-07202  
 PRIMARY METALLURGICAL PROCESSING A-05005, A-07963, A-09686, A-09785, A-17610, A-20585, A-22540, A-24013, A-25549, B-00107, B-00975, B-08837, B-09784, B-09789, B-26063, C-21663, D-22812, L-00973, L-06961, L-09677, L-22466, M-14805  
 PROCESS MODIFICATION A-02334, A-03155, A-03868, A-03870, A-05465, A-05492, A-05493, A-05494, A-05495, A-05520, A-05878, A-05969, A-06086, A-07561, A-09026, A-09663, A-09671, A-10418, A-10433, A-10675, A-11447, A-11968, A-14367, A-20153, A-20737, A-21492, A-21952, A-22642, A-22862, A-24421, A-24767, A-25220, B-01064, B-01935, B-01936, B-01938, B-01944, B-01947, B-02232, B-02394, B-02396, B-02398, B-02400, B-04838, B-05498, B-05852, B-06084, B-06096, B-06315, B-06588, B-07426, B-07769, B-07921, B-08178, B-08837, B-09823, B-09826, B-10009, B-12080, B-14364, B-14522, B-14612, B-15396, B-16536, B-20728, B-20773, B-21626, B-22757, B-22821, B-22822, B-23542, B-23819, B-23836, F-01798, I-19325, J-01294, J-11114  
 PROPANES F-01798  
 PROPELLER AIRCRAFT N-00164  
 PROPIONALDEHYDES F-01798  
 PROPOSALS A-05815, A-11803, A-14923, A-22862, L-25480, L-25688  
 PUBLIC AFFAIRS A-14972, B-00582, B-00975, B-02400, L-08826, M-06085, M-14805, M-15002  
 PUBLIC INFORMATION B-00582  
 PULVERIZED FUELS A-01788, A-05494, B-08837  
 PYRENES A-00972, A-01788, A-05005, A-10424, A-25549, B-10694, F-01798, L-08976  
 PYROLYSIS A-07659, A-11475, A-22642, A-22862, B-25977, F-01798

## Q

QUESTIONNAIRES A-22860, B-02399, M-06085

## R

RADIATION COUNTERS C-02369  
 RADIATION MEASURING SYSTEMS A-10418, C-02369  
 RADIOACTIVE RADIATION B-06315, B-23856, C-02369, I-14737, L-11095, L-20133  
 RAGWEED D-02833  
 RAIN N-22326  
 RAPPING B-09789  
 RATS G-23167  
 REACTION KINETICS A-05465, A-05969, A-09676, A-11475, A-20906, A-23584, B-20078

REACTION MECHANISMS F-01798, L-07879  
 RECORDING METHODS A-10418, B-02232, B-02388, C-15533, D-03454  
 REDUCTION A-07659, A-09676, B-07921, I-12055  
 REFRACTORIES A-05465, A-05495, A-25056, B-09823, B-09824, B-09826, B-10009, I-12055  
 REGIONAL GOVERNMENTS B-07973, L-23126  
 REGULATIONS A-13112, A-23313, A-23314, B-00107, B-00288, B-00975, B-08632, B-09784, B-14522, B-21626, K-12118, L-00973, L-03805, L-06961, L-07202, L-08826, L-08976, L-09500, L-09677, L-09916, L-10567, L-11095, L-12511, L-12989, L-19059, L-25480, L-25688, M-24009  
 RENDERING A-09785, B-09784, B-25977, L-09677, L-09916, L-19059  
 RESEARCH INSTITUTES A-18009  
 RESEARCH METHODOLOGIES B-23008, D-00149, L-07879  
 RESEARCH PROGRAMS A-22862, B-07973, B-15544, L-07879, L-10454  
 RESIDENTIAL AREAS A-05815, A-08850, A-10675, B-06096, B-09823, K-07595, L-07522, L-08976, L-09514, L-09677, L-10567  
 RESIDUAL OILS A-00673, A-00943, B-04843, J-11114  
 RESPIRATORY DISEASES A-17604, A-21991, D-03454, G-01941, G-23167  
 RESPIRATORY SYSTEM A-17604, A-20585  
 RHODE ISLAND L-09677  
 RINGELMANN CHART A-02414, A-06086, B-00975, B-02153, B-09784, B-16730, B-21626, C-04117, L-00973, L-03805, L-09500, L-09677, L-10567, L-19059, L-22466  
 RIVERS B-10694  
 RUBBER A-05492, A-08850, A-10424, A-11450, B-09784  
 RUBBER MANUFACTURING A-03870

## S

SAFETY EQUIPMENT A-03155  
 SALTZMAN METHOD D-22812  
 SAMPLERS A-05005, A-06370, A-21991, A-22540, B-00975, B-06315, B-12655, B-18252, B-19550, C-01612, C-07077, C-15533, C-21663, C-24412, D-22812, F-01798, L-10491  
 SAMPLING METHODS A-00027, A-01788, A-05005, A-05160, A-05718, A-06370, A-08583, A-09026, A-21991, A-22540, A-24582, B-00968, B-00975, B-01947, B-02232, B-04843, B-05874, B-06096, B-06315, B-07426, B-09784, B-12655, B-14967, B-18252, B-19550, B-19896, B-21626, C-01612, C-02260, C-04117, C-06095, C-07077, C-08675, C-11088, C-14368, C-15533, C-19580, C-21663, C-24412, D-22812, F-01798, L-02393, L-03805, L-09916, L-10491  
 SAMPLING PROBES A-01788, A-06370, B-06096, F-01798  
 SAN FRANCISCO A-03154, B-00288, B-07973, L-00973, L-09677  
 SCRAP YARDS A-09676  
 SCREEN FILTERS A-23815



# SUBJECT INDEX

93

- SCRUBBERS A-00972, A-02334, A-02773, A-03155, A-05005, A-05495, A-05718, A-07804, A-09686, A-11432, A-11638, A-11651, A-16514, A-17604, A-17610, A-18173, A-19547, A-20585, A-22642, A-22862, A-23815, A-25862, A-26204, B-00107, B-00968, B-00975, B-01064, B-01935, B-01940, B-02153, B-02186, B-02390, B-02399, B-02402, B-02488, B-02738, B-02976, B-05498, B-06096, B-06315, B-06588, B-07769, B-08632, B-08727, B-09784, B-10455, B-11792, B-12651, B-12655, B-13363, B-14061, B-14364, B-14365, B-14613, B-18252, B-19550, B-19597, B-19896, B-19987, B-20730, B-22757, B-23482, B-23542, B-24089, B-25511, B-25706, B-26063, C-21663, J-02392, K-14366, L-08976, L-10491
- SEASONAL A-10424, A-11411, A-11447, A-11647, A-11666, A-11962, C-07077, D-00149, L-25480, L-25688
- SECONDARY AIR A-05465, A-06086, B-02232, B-06096, B-06315, B-09823, B-22821, F-01798
- SEDIMENTATION A-09686, A-11432, B-09784, B-19550
- SETTLING CHAMBERS A-02334, A-05495, A-19547, A-22862, B-01940, B-01947, B-02153, B-02186, B-02399, B-02738, B-05498, B-05852, B-06084, B-07426, B-08632, B-13133, B-14365, B-19550, B-19896, B-19987, C-21663
- SETTLING PARTICLES A-02009, A-03155, A-05005, A-07561, A-07804, A-08373, A-08583, A-09671, A-09785, A-10418, A-10424, A-10433, A-10678, A-11429, A-11461, A-13112, A-13622, A-14972, A-17552, A-20646, A-21882, A-22130, A-22642, A-22860, A-22862, A-24421, A-25056, A-25549, A-26204, B-00107, B-00968, B-00975, B-01437, B-01935, B-01937, B-01939, B-01940, B-01947, B-02027, B-02153, B-02387, B-02390, B-02397, B-02398, B-02400, B-02976, B-06096, B-06315, B-07426, B-08727, B-08837, B-09784, B-09789, B-10009, B-11658, B-11792, B-13363, B-13697, B-14364, B-14365, B-14369, B-14736, B-16137, B-17403, B-18252, B-21058, B-21626, B-22156, B-23262, B-23482, B-23542, B-26063, C-04117, C-17352, C-17468, C-23437, C-24412, D-03454, H-09275, K-14366, K-22389, L-02392, L-06741, L-06961, L-07202, L-08976, L-09677, L-12989, L-16343, L-19059, L-20133, L-22466, N-01531
- SEWAGE A-00673, A-03155, A-08850, A-11432, A-11961, A-11963, A-11971, A-17462, A-25056, B-00582, B-02389, B-02390, B-07769, B-12080, B-13697, B-14940, B-24089, L-23126, L-23765
- SEWAGE TREATMENT A-08850, A-11961, A-11963, B-13697, B-14940
- SEWERS A-08850
- SHIPS A-09785, N-00164
- SIEVE ANALYSIS B-00968
- SILICATES A-09785, B-09784
- SILICON COMPOUNDS A-09785, B-01947, B-09784
- SILVER COMPOUNDS A-09785
- SIMULATION A-11475, A-20906, B-01935
- SINGLE CHAMBER INCINERATORS A-00712, A-05005, A-05465, A-05520, A-05718, A-05969, A-07561, A-07804, A-10675, A-12441, B-00968, B-01064, B-02186, B-09823, B-09826, B-13133, B-16751, B-18252, B-19550, B-22757, C-08675, K-07595, L-07522, M-06085, N-00164
- SINTERING A-00972, L-06961, L-07202
- SKIN A-21991
- SLUDGE A-03155, A-08850, A-11432, A-11961, A-11963, A-11971, A-17462, A-25056, B-02389, B-02390, B-07769, B-12080, B-13697, B-14940, B-24089, L-23126
- SMOG A-09785, A-25549, B-00107, B-00975, B-20294, B-25511, C-24412
- SMOKE SHADE A-02414, A-06086, A-10418, B-00975, B-02153, B-09784, B-16730, B-19896, B-21626, C-04117, L-00973, L-03805, L-09500, L-09677, L-10567, L-19059, L-22466
- SMOKEMETERS A-05718, A-10418, C-02391, L-09500
- SMOKES A-00712, A-02334, A-02414, A-05005, A-05465, A-05718, A-05815, A-06086, A-07206, A-07561, A-07804, A-08090, A-08373, A-08583, A-09785, A-10424, A-14367, A-17462, A-17552, A-19052, A-20276, A-20646, A-22130, A-22642, A-22860, A-23313, B-00107, B-00183, B-00246, B-00288, B-00975, B-02153, B-02232, B-05852, B-05874, B-07426, B-08837, B-09789, B-09823, B-09826, B-14365, B-14967, B-16137, B-20730, B-21058, B-21435, B-21626, B-22821, B-22822, B-23008, B-23262, B-23836, B-25511, B-25570, B-25706, C-02391, C-04117, C-20808, D-03454, H-09275, K-14366, K-17201, L-00973, L-03805, L-06961, L-07202, L-07522, L-09677, L-09916, L-10567, L-16343, L-20133, N-01531, N-22326
- SOAP MANUFACTURING B-09784
- SOCIAL ATTITUDES M-06085
- SOCIO-ECONOMIC FACTORS B-12664, B-14613, L-23765, M-24009
- SODIUM COMPOUNDS B-01947, B-04838, B-16749
- SOILING N-00164
- SOILING INDEX B-00975, C-24412, L-25688
- SOILS A-05492
- SOLAR RADIATION G-23293
- SOLID WASTE DISPOSAL A-00673, A-00712, A-00972, A-01788, A-02009, A-02334, A-02414, A-02773, A-03155, A-03868, A-03870, A-05005, A-05465, A-05492, A-05493, A-05494, A-05495, A-05497, A-05651, A-05877, A-05878, A-05969, A-06086, A-06852, A-06937, A-07206, A-07561, A-07659, A-07804, A-08090, A-08373, A-08577, A-08583, A-08816, A-08850, A-09026, A-09158, A-09663, A-09671, A-09676, A-09785, A-10038, A-10418, A-10433, A-10675, A-10678, A-11411, A-11412, A-11413, A-11427, A-11428, A-11429, A-11430, A-11431, A-11432, A-11438, A-11439, A-11440, A-11447, A-11448, A-11449, A-11450, A-11461, A-11636, A-11637, A-11638, A-11640, A-11647, A-11649, A-11651, A-11655, A-11657, A-11666, A-11934, A-11939, A-11940, A-11961, A-11968, A-11971, A-11972, A-13622, A-14367, A-14442, A-14923, A-17243, A-17462, A-17552, A-17604, A-18009, A-18173, A-19052, A-21492, A-22860, A-23025, A-23313, A-23314, A-24013, A-25220, A-25549, A-25862, A-26204, B-00288, B-00582, B-00975, B-01437, B-01935, B-01937, B-01938, B-01943, B-01944, B-01945, B-01946, B-01947, B-02027, B-02153, B-02232, B-02388, B-02389, B-02390, B-02394, B-02397, B-02398, B-02399, B-02400, B-02401, B-02738, B-02741, B-03229, B-04843, B-05498, B-05569, B-05570, B-05852, B-05874, B-06084, B-06096, B-06315, B-06588, B-07769, B-07973, B-08632, B-08727, B-09784, B-09823, B-09826, B-10009, B-10694, B-11652, B-11658, B-11792, B-12080, B-14061, B-14364, B-14369, B-14522, B-14524, B-14612, B-14613, B-16536, B-16730, B-16749, B-16751, B-17275, B-17403, B-19597, B-19941, B-20730, B-21626, B-22808, B-23008, B-23836, B-24954, B-25977, C-02391, C-11088, D-02395, D-02833, D-03454, F-01798, F-09284, G-01941, H-09275, I-12055, J-01294, J-02392, J-03006, J-11857, L-00973, L-01948, L-02393, L-03805, L-05496, L-07522, L-07879, L-09500, L-09677, L-09916, L-10454, L-10491, L-11095, L-20133, L-23126, L-23765, N-00164, N-01531
- SOLIDS A-00673, A-03155, C-23437, F-13618
- SOLVENTS A-09785, B-00107, B-09784, C-21663, L-08826, L-09677, L-09916
- SOOT A-02009, A-03155, A-08373, A-10424, A-22130, A-22642, A-22860, A-25549, A-26204, B-02153, B-06315, B-21058, B-26063, C-23437, L-06741, L-07202
- SOOT FALL D-03454
- SOURCE SAMPLING A-08583, A-24582, B-00968, B-00975, B-01947, B-02232, B-19550, B-19896, C-02260, C-04117, C-06095, C-07077, C-11088, C-15533, C-19580, L-02393
- SO2 REMOVAL (COMBUSTION PRODUCTS) A-22540, A-23815, A-26204, B-08837, B-18252
- SPARK IGNITION ENGINES A-00673, A-05005, A-09686, B-15544, D-00149, L-08976, N-00164
- SPARK TIMING B-20294
- SPECTROMETRY A-00027, A-01788, A-05005, A-08373, A-21991, B-02232, D-03454, D-22812, F-01798
- SPECTROPHOTOMETRY A-00027, A-01788, B-00968, B-12655, C-21663, D-22812, F-01798
- SPORES A-20517
- SPOT TESTS A-08373
- SPRAY TOWERS A-05005, A-05495, A-23815, B-06315, B-08632, B-18252, B-25511, L-10491
- ST LOUIS A-03870, B-00968, B-01064, B-01935, B-01936, B-01937, B-01944, B-02232, B-02394, B-02397, L-09677
- STABILITY (ATMOSPHERIC) A-09785, A-10424, A-10678, A-14972, B-00975, L-08976, M-24009
- STACK GASES A-01788, A-05651, A-05718, A-06086, A-07206, A-07561, A-08583, A-09663, A-09671, A-09686, A-10418, A-10433, A-11411, A-11412, A-11413, A-11427, A-11428, A-11429, A-11430, A-11431, A-11432, A-11438, A-11439, A-11440, A-11447, A-11448, A-11449, A-11450, A-11461, A-11636, A-11637, A-11638, A-11640, A-11647, A-11649, A-11651, A-11655, A-11657, A-11666, A-11934, A-11939, A-11940, A-11961, A-11968, A-11971, A-11972, A-13622, A-14367, A-14442, A-14923, A-17243, A-17462, A-17552, A-17604, A-18009, A-18173, A-19052, A-21492, A-22860, A-23025, A-23313, A-23314, A-24013, A-25220, A-25549, A-25862, A-26204, B-01935, B-01937, B-01947, B-02153, B-02186, B-02232, B-02387, B-02390,



## MUNICIPAL INCINERATORS

B-02398, B-03229, B-06084, B-06096, B-06315, B-08632, B-08837, B-09784, B-09823, B-09824, B-09826, B-10009, B-13133, B-14369, B-14613, B-17403, B-19597, B-19896, B-21058, B-21626, B-22296, B-23836, B-23856, B-24465, B-26063, C-02260, C-02391, C-04117, C-05834, C-06095, C-08257, C-14368, C-15533, C-24412, D-02395, D-22812, H-09275, I-19325, J-02392, K-14366, L-07522, L-09677, L-10567, L-16343, L-22466

**STACK SAMPLING** A-08583, B-00968, B-00975, B-01947, B-02232, B-19550, B-19896, C-02260, C-04117, C-06095, C-07077, C-11088, C-15533, C-19580, L-02393

**STACKS** A-02334, A-03868, A-07804, A-10678, A-11413, A-14442, A-17462, A-22130, A-22860, A-24421, A-25862, B-00183, B-00968, B-01938, B-02397, B-02398, B-04838, B-07426, B-09823, B-09824, B-09826, B-12651, B-16730, B-16751, B-19896, B-20078, B-25511, C-02260, C-02369, C-07077, C-20808, K-07595, K-22389, L-02393, L-08976, L-09500, L-11095, L-20133

**STANDARDS** A-01788, A-05718, A-07804, A-08583, A-10675, A-11461, A-11638, A-11649, A-12441, A-16514, A-19052, A-21882, A-22862, A-25549, B-00288, B-00975, B-01939, B-01942, B-02153, B-02389, B-02390, B-02396, B-02400, B-02401, B-08632, B-14364, B-14365, B-14369, B-16751, B-21626, C-04117, C-08675, D-02395, J-01294, K-12118, K-14366, K-17201, K-22375, K-22389, L-00973, L-02393, L-03805, L-06961, L-07202, L-08826, L-09500, L-09677, L-09916, L-10491, L-10567, L-11095, L-19059, L-20861, L-22466, L-23126, L-25480, L-25688, M-24009, N-01531

**STATE GOVERNMENTS** A-23313, A-23314, B-00975, B-07973, L-01948, L-03805, L-06961, L-09514, L-09677, L-09916, L-12511, L-18108, L-25480, L-25688, M-24009

**STATISTICAL ANALYSES** J-11857

**STEAM** A-01788, A-05492, A-05493, A-09663, A-11428, A-23025, B-01935, B-14613, B-21058, B-25706, C-20808

**STEAM PLANTS** A-05160, A-05494, A-06937, A-07206, A-07963, A-09663, A-09785, A-10038, A-10424, A-11411, A-11413, A-11640, A-11655, A-11803, A-11968, B-02397, B-09784, B-09789, B-10009, B-10694, C-06095, J-11114, L-18108, L-23765, N-00164, N-22326

**STEEL** A-00972, A-05005, A-09686, A-16869, B-08837, B-09789, B-09824, B-09826, I-24187, L-00973, L-22466

**STONE** A-05492, A-09686

**STREETS** L-08976, L-09514

**SUBLIMATION** F-01798

**SULFATES** A-09785, I-14737

**SULFIDES** A-05815, A-09785, B-00975, B-02389, B-02390, B-02488, B-04838, B-07921, D-22812, I-12055

**SULFUR COMPOUNDS** A-05492, A-05497, A-05815, A-09785, A-23313, A-23314, A-26204, B-00975, B-01947, B-02389, B-02390, B-02488, B-04838, B-07921, D-02395, D-22812, I-12055, I-14737, L-00973, L-09677, L-09916

**SULFUR DIOXIDE** A-00673, A-00943, A-00972, A-02009, A-05492, A-07561,

A-07963, A-08583, A-09026, A-09686, A-09785, A-10678, A-11438, A-11649, A-11803, A-19052, A-21952, A-24013, A-25220, B-00107, B-00975, B-02153, B-02390, B-04838, B-10694, B-14369, B-16730, B-18252, C-06095, C-17468, D-00149, D-03454, D-22812, G-23293, L-00973, L-07202, L-08976, L-09514, L-09677, L-18108, L-20861, L-25688, M-14805, N-22326

**SULFUR OXIDES** A-00673, A-00943, A-00972, A-01788, A-02009, A-05492, A-05815, A-07561, A-07963, A-08583, A-09026, A-09686, A-09785, A-10678, A-11438, A-11649, A-11803, A-19052, A-20646, A-21952, A-22862, A-24013, A-25220, B-00107, B-00975, B-01947, B-02153, B-02390, B-04838, B-08727, B-08837, B-09784, B-10694, B-14369, B-16730, B-16749, B-18252, B-23008, C-06095, C-17468, C-21663, D-00149, D-02833, D-03454, D-22812, G-01941, G-23293, I-12055, I-19325, J-11114, L-00973, L-07202, L-08976, L-09500, L-09514, L-09677, L-11095, L-12511, L-18108, L-19059, L-20861, L-25480, L-25688, M-14805, N-22326

**SULFUR OXIDES CONTROL** A-18173, A-22540, A-23815, A-26204, B-00107, B-08727, B-08837, B-18252

**SULFUR TRIOXIDE** A-00972, A-08583, A-09026, A-09686, A-09785, A-11438, A-11649, B-00107, B-01947, B-04838, B-08727, B-16730, B-16749, G-01941, I-12055

**SULFURIC ACID** A-09676, A-09686, A-25549, B-09784, B-09789, B-16749, G-01941

**SUPERSATURATION** B-14613

**SURFACE COATING OPERATIONS** A-09686, A-09785, A-22873, B-09784, L-08826

**SURFACE COATINGS** A-09686, C-07077, D-03454

**SURVEY METHODS** C-04117

**SUSPENDED PARTICULATES** A-00712, A-00972, A-02009, A-02334, A-02414, A-05005, A-05465, A-05718, A-05815, A-06086, A-07206, A-07561, A-07804, A-08090, A-08373, A-08583, A-09158, A-09686, A-09785, A-10424, A-10433, A-11411, A-11412, A-11413, A-11427, A-11431, A-11432, A-11651, A-11934, A-11971, A-14367, A-14972, A-17462, A-17552, A-17604, A-19052, A-20153, A-20276, A-20646, A-20737, A-20759, A-22130, A-22642, A-22860, A-22862, A-23313, A-25220, A-25549, A-25862, B-00107, B-00183, B-00246, B-00288, B-00968, B-00975, B-01437, B-01935, B-01936, B-01937, B-01938, B-01940, B-01946, B-01947, B-02153, B-02232, B-02389, B-02399, B-02402, B-02738, B-04843, B-05852, B-05874, B-06096, B-06588, B-07426, B-07921, B-08632, B-08837, B-09784, B-09789, B-09823, B-09824, B-09826, B-10009, B-10694, B-14364, B-14365, B-14967, B-16137, B-16730, B-18252, B-19550, B-19896, B-19987, B-20294, B-20730, B-21058, B-21435, B-21626, B-22821, B-22822, B-23008, B-23262, B-23542, B-23836, B-25511, B-25570, B-25706, C-02260, C-02369, C-02391, C-04117, C-15533, C-20808, C-24412, D-03454, H-09275, I-24187, K-14366, K-17201, L-00973,

L-03805, L-06961, L-07202, L-07522, L-09500, L-09514, L-09677, L-09916, L-10567, L-16343, L-19059, L-20133, L-25688, N-01531, N-22326

**SWEDEN** A-00027, A-00972, A-01788, A-03155, A-03870, A-07659, B-00183, B-00975, B-01935, B-01936, B-01947, B-02388, B-02389, B-02390, B-02394, B-02396, B-02397, B-02400, B-02401, B-02402, C-02369, C-23437, D-03454, F-01798, J-02392, L-02393, L-03805

## T

**TAR** A-09676

**TAXATION** A-09676

**TECHNICAL SOCIETIES** L-08826

**TEFLON** D-00149

**TEMPERATURE** A-05465, A-05651, A-05878, A-07561, A-07804, A-08090, A-09026, A-09676, A-10433, A-10675, A-11427, A-11447, A-20276, A-20517, A-20646, A-22642, A-23584, A-23815, A-24241, A-24421, B-00968, B-01064, B-01935, B-01936, B-01937, B-01944, B-02232, B-02394, B-02397, B-05852, B-06084, B-06096, B-06588, B-07921, B-09789, B-09823, B-13697, B-15201, B-20078, B-20773, B-23482, B-24465, B-25570, C-11088, F-13618, F-14370, I-12055, I-14737, I-19325, L-08826

**TEMPERATURE (ATMOSPHERIC)** A-09785, A-10424, G-23293, L-09916, M-24009

**TEMPERATURE SENSING INSTRUMENTS** A-10418

**TENNESSEE** L-19059

**TESTING FACILITIES** A-10424, A-20906, A-23584, B-20078, C-01612

**TEXTILE MANUFACTURING** A-09686

**TEXTILES** A-05492, A-08850, A-18009, D-03454

**THERMODYNAMICS** A-11972, A-16254, B-01935, B-02396, F-13618

**THRESHOLDS** L-09916

**TIN** B-09789

**TIRES** A-09026, A-10424, B-10694

**TITANIUM COMPOUNDS** A-09785, B-01947

**TOLUENES** A-23584, B-02389, F-01798, L-08826

**TOPOGRAPHIC INTERACTIONS** A-69785, D-02833

**TOXICITY** A-17604, A-17610, A-20585, A-21991

**TRADE ASSOCIATIONS** K-12118

**TRAINS** A-03154, A-09785, A-10424, A-25549, B-00975, B-07973, D-02833, N-00164

**TRANSMISSOMETERS** A-10418

**TRANSPORT** A-11450

**TRANSPORTATION** A-00673, A-00972, A-03154, A-05005, A-05815, A-05969, A-09686, A-09785, A-10424, A-11803, A-20585, A-21991, A-22540, A-24013, A-25549, B-00975, B-07973, B-08837, B-10694, B-15544, B-20294, B-24954, C-21663, C-24412, D-00149, D-02833, D-03454, G-23167, G-23293, J-11857, L-08976, L-09514, L-09677, L-09916, L-19059, L-23765, N-00164

**TRAPPING (SAMPLING)** A-05005, C-08675

**TREATED FABRICS** B-08727

**TREATMENT AND AIDS** G-23293, I-24187

**TRUCKS** A-05005, B-00975, D-00149, L-08976, L-19059, N-00164

# SUBJECT INDEX

95

TURBULENCE (ATMOSPHERIC)  
A-10675, B-01064, B-04838

## U

ULTRAVIOLET SPECTROMETRY  
A-01788, A-03005, D-22812, F-01798  
UNDERFIRE AIR A-05969, A-06086,  
A-22642, A-22862, A-25220, B-01064,  
B-02232, B-05498, B-09823, B-09826,  
B-10009  
UNITED STATES A-00712, A-10424,  
A-11447, A-11638, B-00183, B-02399,  
B-06588, B-08632  
URBAN AREAS A-02009, A-02414,  
A-05815, A-07206, A-08577, A-08850,  
A-09676, A-09785, A-10433, A-10675,  
A-11428, A-11439, A-11447, A-11448,  
A-11803, A-12441, A-14923, A-22540,  
A-22860, A-22862, B-00183, B-01945,  
B-03229, B-06096, B-09823, B-11658,  
B-15201, B-23542, D-00149, D-03454,  
D-22812, F-01798, J-03006, K-07595,  
L-07522, L-08976, L-09500, L-09514,  
L-09677, L-10567, L-11095, L-25480,  
L-25688  
URINALYSIS B-00975, D-03454, N-00164  
USSR A-00712, B-08178

## V

VALLEYS B-00975

VANADIUM COMPOUNDS A-09785,  
G-23167, I-12055  
VAPOR RECOVERY SYSTEMS A-09663,  
B-14613, C-21663  
VAPORS A-01788, A-05492, A-05493,  
A-09663, A-11428, A-23025, B-01935,  
B-14613, B-21058, B-25706, C-20808  
VEGETABLES A-06086, A-08850  
VEHICLES A-00972, A-03154, A-05005,  
A-05815, A-09686, A-09785, A-10424,  
A-11803, A-21991, A-24013, A-25549,  
B-00975, B-07973, B-10694, C-21663,  
D-00149, D-02833, D-03454, G-23293,  
L-08976, L-09514, L-09916, L-19059,  
L-23765, N-00164  
VENTILATION B-01938, B-08837, B-23836  
VENTURI SCRUBBERS B-08632, B-19987,  
B-24089  
VIRGINIA A-05493  
VISIBILITY A-09785, B-00975, D-03454  
VOLATILITY B-04843  
VOLTAGE B-09789, C-08257

## W

WASHINGTON D C I-09677  
WATER A-05465, A-05492, A-05497,  
A-05969, A-06086, A-09676, A-14923,  
A-20276, A-23815, B-01935, B-01947,  
B-06096, B-19896, B-20773, C-20808  
WATER POLLUTION A-07659, A-08850,  
A-18009, B-07769, B-14369, K-14366,

L-20133, L-23126, L-23765  
WEATHER MODIFICATION B-07973  
WEST AND GAEKE METHOD C-17468  
WEST VIRGINIA L-09677  
WET CYCLONES A-02773, A-11432,  
B-01940, B-02186, B-02738, B-02976,  
B-08727, B-14364, B-14365, B-26063,  
J-02392, K-14366  
WETTING B-21058  
WIND ROSE D-03454, L-08976  
WINDS A-09785, A-10678, A-23313,  
B-00975, D-03454, G-23293, L-08976,  
L-09514, L-25480, L-25688, M-24009,  
N-22326  
WISCONSIN B-00968, B-06096, J-03006,  
L-00973  
WOOD A-05465, A-05492, A-06086,  
A-06370, A-08850, A-09026, A-09676,  
A-11450, A-18009, B-05570, B-09784,  
B-09823, B-09824, B-25570

## X

X-RAYS I-14737

## Y

YOKOHAMA A-22130

## Z

ZINC A-09686, B-00107, B-09784, B-09789